Saskatchewan
Agriculture, Food
and Rural
Revitalization

ADF

AGRICULTURE DEVELOPMENT FUND

FINAL REPORT

20000232

DEVELOPMENT OF INTEGRATED PEST MANAGEMENT STRATEGIES FOR CONTROL OF ENTOMOSPORIUM LEAF AND BERRY SPOT AND SASKATOON-JUNIPER RUST IN SASKATOON ORCHARDS

Funded by: The Agriculture Development Fund

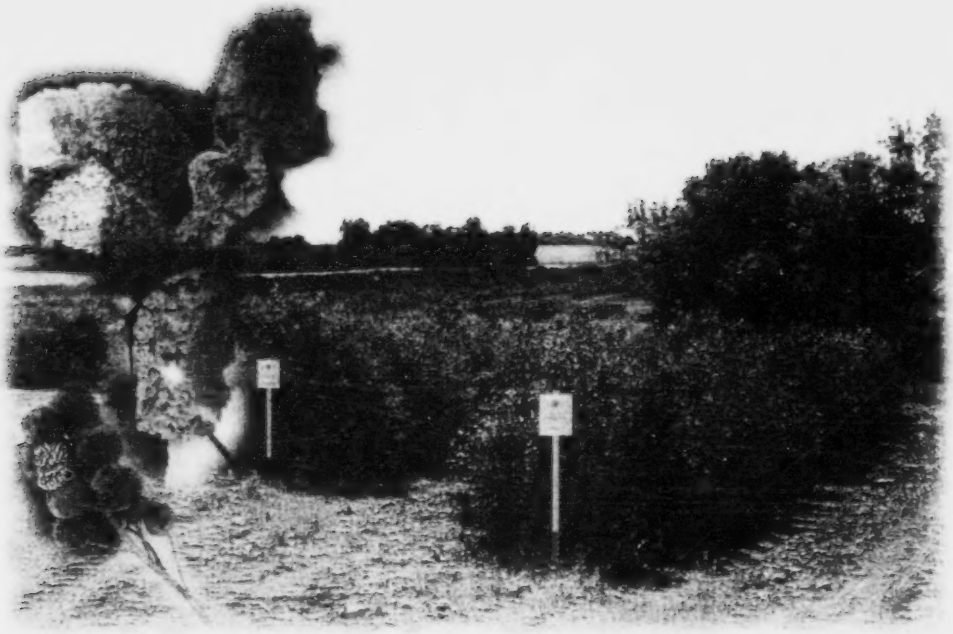
March, 2005

Prepared by: University of Saskatchewan

105-04377/

Development of Integrated Pest Management Strategies for Control of *Entomosporium* Leaf and Berry Spot and Saskatoon-Juniper Rust in Saskatoon Orchards

ADF Project # 20000232
Final Report 2005



Jill Thomson, Richard St-Pierre and Robert Bors
Department of Plant Sciences
University of Saskatchewan
Saskatoon

TABLE OF CONTENTS

1. **Abstract**.....3

2. **Executive Summary**.....3

3. **Technical Report**.....5
   - **3.1 Background**.....5
   - **3.2 Materials And Methods**.....7
     - 3.2.1. Study sites.....7
     - 3.2.2. Data collection and statistical analysis.....7
   - **3.3 Experiments Conducted**.....8
     - 3.3.1. Observation of naturally infected material to determine the over-wintering mechanism of *E. mespili*.....8
     - 3.3.2. Monitoring of the spore production of *E. mespili* in saskatoon bushes.....11
     - 3.3.3. Evaluation of fungicide efficacy for control of *Entomosporium* leaf and berry spot and saskatoon-juniper rust.....12
     - 3.3.4. Influence of pruning on disease development in saskatoons.....22
     - 3.3.5. Evaluation of mulching as a method for controlling diseases and insect damage to saskatoons.....29
     - 3.3.6. Evaluation of saskatoon material for resistance to *Entomosporium* leaf and berry spot and saskatoon-juniper rust.....37
   - **3.4 Conclusions**.....41
   - **3.5 Figures**.....44

4. **Personnel**.....56

5. **Equipment**.....56

6. **Project Developed Materials**.....56

7. **Project Photos**.....57

8. **Acknowledgements**.....57

1. ABSTRACT

Entomosporium mespili, the pathogen causing leaf and berry spot of saskatoon, survives the winter on infected plant material. Spores are produced in the spring on leaves, fruit and pedicels, and on detached leaves under the bushes. A custom-built spore sampler used to collect splash-dispersed spores was not effective in detecting the inoculum causing early leaf infections. BAS 516, a new, unregistered fungicide was capable of controlling leaf and berry spot and rust (*Gymnosporangium* spp.). Application of FungiNeem and Melaleuca oil did not reduce disease levels. Application of Topas and BAS 516 significantly decreased the incidence of brown fruit rot (*Monilinia amelanchieris*). BAS 516 could be a valuable alternative control product for use by saskatoon producers. Pruning treatments initiated in 2002 reduced leaf and berry spot at several sites, but no control occurred in the following season. Yield was increased by pruning at the recommended level, confirming the value of this practice. Applying a layer of wood-chip mulch under saskatoon bushes reduced disease and insect damage at several sites, and early defoliation was also visibly reduced. For further information, refer to the Final Report online.

2. EXECUTIVE SUMMARY

The objective of this project was to develop integrated pest management strategies for control of *Entomosporium* leaf and berry spot and saskatoon-juniper rust (*Gymnosporangium* spp.) in saskatoon orchards. These two fungal diseases significantly reduce fruit production and quality if protectant fungicides are not applied at the correct times. In some seasons, significant damage occurs even when a spray program is in place.

Integrated pest management (IPM) uses a variety of techniques to reduce the impact of diseases and pests on cultivated crops. These techniques include the use of chemical products, and also measures that reduce the reliance of producers on pesticides. Development of IPM techniques requires an understanding of the life cycles and epidemiology of the pathogens involved, so that the relationships of inoculum potential, life cycles, microclimate and orchard practices can be determined. Once these interactions are understood, specific techniques can be developed to reduce the impact of diseases.

Development of disease in the spring relies on a source of overwintering inoculum. Plant material naturally infected with *Entomosporium mespili* (the fungal pathogen that causes leaf and berry spot of saskatoon) was collected from saskatoon bushes in the spring of 2001, 2002 and 2003. Spores were produced on detached leaves collected from under bushes, and attached leaves, fruit, and pedicels, after incubation under moist conditions at room temperature. Infected fruit was frequently the most prevalent source of spores. This demonstrated that the pathogen can survive the winter on infected plant material, which then provides an inoculum source for *E. mespili* under conditions suitable for disease development.

Early detection of the spores of *E mespili* in an orchard would permit fungicide spray programs to be modified according to inoculum pressure. Movement of spores within an orchard was monitored from June to August 2003, using a spore sampler developed at the University of Manitoba. *E. mespili* spores were trapped by the sampler only after rainfall in August. The inoculum that initiated early leaf infections was not detected by this method. The spore sampler did not appear to be a useful tool for early detection of spores.

Control of *Entomosporium* leaf and berry spot and saskatoon-juniper rust by different fungicides was evaluated at several trial sites, over four years (2001-2004). Topas is the registered product used in most saskatoon orchards and Sovran is registered for control of apple scab. In 2001 leaf and berry spot was reduced later in the season by applications of Sovran and Topas in early August. However label expansion to include application of Sovran on saskatoons was not feasible. In 2002- 2004 the efficacy of a new BASF product (BAS 516) was compared with that of Topas. Both Topas and BAS 516 were effective in controlling leaf and berry spot infections. Both products also controlled rust infections, but in 2004 BAS 516 was not quite as effective as Topas in controlling rust. Topas and BAS 516 also significantly reduced the level of brown fruit rot (*Monilinia amelanchieris*) in one spray trial in 2003. The organic-type products FungiNeem and Melaleuca oil were not effective in reducing disease levels, and over-application of FungiNeem resulted in blackening of saskatoon leaves. BAS 516 would be a valuable tool for saskatoon growers, as it would reduce the risk of development of pathogen resistance to fungicides by providing a product with alternative chemistry.

Removal of plant material within rows of saskatoon bushes should increase airflow and decrease humidity, altering the microclimate of the bushes, and the conditions conducive for disease development. Pruning significantly reduced the levels of leaf and berry spot in two pruning trials in 2002. Monitoring of the two trials was continued in 2003. There were no significant differences in disease levels in 2003. However, yield data collected at one site showed that the 1/3 removal of plant material had significantly improved yield in the following season, demonstrating the beneficial effect on yield of pruning at the recommended rate. Pruning is necessary to remove damaged wood, and the older, less productive stems. It also increases production as removal of at least 1/3 of the older plant material in a row increased the yield of fruit.

A thick layer of mulch applied under rows of saskatoon bushes would cover detached leaves and lower the amount of fungal inoculum available in the spring, providing an IPM control strategy. A preliminary trial to determine the effect of mulching on subsequent disease development was initiated at Lormar Orchard in April 2003. Significantly less insect damage developed on the leaves of the mulched bushes, and there were also lower levels of leaf and berry spot. In 2004 there was visibly less defoliation of leaves in mulched areas in August, at two sites. Early defoliation is usually caused by *Entomosporium* infection. The incidence of berry spot was also significantly less at one site, when mulch was applied. These results indicate that the mulching treatment has the potential to be a valuable IPM strategy, and should be evaluated more extensively.

Resistance of different saskatoon genotypes to leaf and berry spot was evaluated using a detached leaf assay technique. Sixteen of the 26 genotypes tested in the laboratory developed less infection than the three commercial cultivars tested. Seedlings from four of the original selections also showed some resistance to *Entomosporium* infection in the field. Further evaluation of this material is recommended because of the potential to develop cultivars resistant to disease.

3. TECHNICAL REPORT

3.1. Background

The objective of this project was to develop integrated pest management strategies for control of *Entomosporium* leaf and berry spot and saskatoon-juniper rust in saskatoon orchards. These two fungal diseases significantly reduce fruit production and quality, if protectant fungicides are not applied at the correct times. In some seasons, significant damage occurs even when a spray program is in place.

Integrated pest management (IPM) uses a variety of techniques to reduce the impact of diseases and pests of cultivated crops. These techniques include the use of chemical products, but reduce the reliance of producers on pesticides. Development of IPM techniques requires an understanding of the life cycles and epidemiology of the pathogens involved, so that the relationships of inoculum potential, life cycles, microclimate and orchard practices can be determined. Once these interactions are understood, specific techniques can be developed to reduce the impact of diseases.

Leaf and berry spot of saskatoon is caused by an ascomycete fungus, *Entomosporium mespili*. The pathogen produces distinctive asexual spores (Figure 3.1.1) that are splash-borne during rainfall. Infection results in tiny, necrotic spots that initially pepper the leaf, but may coalesce to form distinct necrotic areas. The fungus sporulates on these lesions in saucer shaped, black acervuli, which appear grey when spores are being produced (Figure 3.1.2). Initial infections are often observed on lower leaves, and upper leaves and fruit are quickly infected under showery conditions. Growers have observed that infection may not be present until a week or so before harvest, and suddenly upper leaves and fruit develop disease symptoms.

Reduction in inoculum levels of disease can result in appreciable reductions in disease development. An understanding of the life cycle of the pathogen involved is necessary in order to determine the most effective time for inoculum reduction. In the saskatoon-juniper rust cycle, the pathogen over-winters on juniper bushes in dormant galls. During moist weather in the spring, the galls produce fleshy structures (Figure 3.1.3) that release spores. These tiny, airborne spores are blown considerable distances. They infect the leaves and fruit of saskatoon bushes, where they form sporulating lesions (aecia) that are disfiguring (Figure 3.1.4) and reduce fruit quality. The aeciospores are released in mid-summer, and are wind-blown to junipers. Infection of junipers leads to production of galls capable of producing spores in springtime. Knowledge of this cycle has led to the

recommendation that saskatoon and juniper bushes should not be grown in proximity to each other.

The precise location of over-wintering inoculum of *E. mespili* has not been determined. Infected leaves, fruit and shoots are all possible sources of over-wintering material. Removal of leaf litter, in an Alberta study, did not reduce disease development, and this led to the assumption that the pathogen did not over-winter on fallen leaves (P. Bains - personal communication). If the source of over-wintering inoculum can be discovered, then procedures to remove this source should result in a reduction of disease. Another method to discover the exact location of over-wintering inoculum is to determine where and when the spores that initiate the first spring infections are produced. Methods to study spore movement require trapping of spores in different locations.

The fungicide most widely used for control of leaf and berry spot is Topas 250E, and this product has a pre-harvest interval of 38 days. Orchards where the fungicide has been applied still develop disease just prior to harvest, suggesting the fungicide does not provide protection against infection for the whole of the pre-harvest period. Techniques to reduce this period of susceptibility would be advantageous to producers. One possibility would be to apply a fungicide with a longer protectant period. Initial studies on the efficacy of Sovran, a fungicide registered for control of apple scab, show that this chemical appeared to control leaf and berry spot for a longer period than Topas.

Infection by *E. mespili* requires not only infective spores, but also a suitable microclimate. Growers have observed that maintaining a more open orchard appears to reduce disease levels. Removal of plant material would allow greater airflow between and through bushes, reducing the humidity and creating conditions less favourable for disease development. Growers ideally prune saskatoon bushes every three to four years. Consequently, removal of a certain percentage of stem material may be an ideal IPM strategy.

Development of saskatoon cultivars resistant to disease would reduce the need for application of chemicals for disease control. This would have both an economic and environmental benefit. The most important foliar pathogens of saskatoon are leaf and berry spot and saskatoon-juniper rust. Ideally new cultivars should be resistant to both pathogens. Screening for resistance using a detached leaf assay method allows rapid evaluation of a variety of genotypes. Genotypes demonstrating resistance in this type of test can then be further evaluated in the field.

3.2. Materials And Methods

A number of experiments were conducted during the four years of this program. Some experiments were repeated every year, with modifications. These experiments are reported by year, after a general materials and methods section.

3.2.1. Study Sites

This project involved the use of eight study sites: a) the Accession Orchard, University of Saskatchewan (U of S) Department of Plant Sciences' Horticultural Field plots in Saskatoon; b) the Cultivar Orchard, University of Saskatchewan, Department of Plant Sciences' Horticultural Field plots in Saskatoon; c) a grower co-operator site south of the City of Saskatoon (Riverbend Plantation, L. and G. Whittington); d) a grower co-operator site near Raymore (Last Mountain Berry Farm, B. Isaac); e) a grower co-operator site at Outlook (W. King); f) a home garden site at Outlook (J. Lynsley); g) a grower co-operator site near Wynyard (Lormar Orchard, L. and M. Lazorko); and h) a grower co-operator site near Edenwold (South Valley Farm, R. Flaman).

3.2.2. Data Collection And Statistical Analysis

The following data were collected, depending on experiment:
Disease incidence – the number of leaves, or fruit, infected with disease, expressed as a percentage.
Disease severity – the % leaf area infected was assessed visually, and a rating value assigned, according to the scale shown in Table 3.2.2.1.

Table 3.2.2.1. Rating Scale For Severity Of *Entomosporium* Leaf Infection.

Disease severity score	% Area of leaf infected
0	0
<1*	<1
1	1-5
2	>5 - 10
3	>10 - 25
4	>25 - 50
5	>50 - 75
6	>75

* analyzed with a numerical value of 0.05

Total yield – total weight of uncleaned fruit that were harvested.
Marketable yield – total weight of cleaned fruit.
10 fruit weight – 10 of the harvested fruit were selected at random and weighed.

Data were analyzed using the SAS GLM procedure. Significant treatment means were compared using the Duncan's Multiple Range test, at P=0.05, the Duncan's Multiple Range test, at P=0.1, or the LSD test at P=0.05.

3.3. Experiments Conducted

3.3.1. Observation Of Naturally Infected Material To Determine The Over-wintering Mechanism Of *E. mespili*

Infected saskatoon leaves, fruit and shoots are all possible sources of overwintering material for the pathogen, *E. mespili*. Removal of leaf litter, in an Alberta study, did not reduce disease development, and this led to the assumption that the pathogen did not overwinter on fallen leaves (P. Bains - personal communication). Identification of the possible sources of overwintering inoculum would enable development of procedures to remove this source. This, in turn, may lead to a reduction of disease. Examination of overwintering material that could act as an inoculum source was conducted for several years at different sites.

2001

Materials And Methods:

Plant material was collected from four sites on a weekly basis, and examined for production of *Entomosporium* spores. The four sites were: 1) the University of Saskatchewan Accession Orchard; 2) Riverbend Plantation; 3) W. King's orchard; and 4) J. Lynsley's garden, Outlook.

Entomosporium infections were observed at all four sites in previous years. The material collected at random from saskatoon bushes at each collection time included 20 detached leaves from around the base of the bushes, ten pedicels and attached fruit, ten attached leaves, and 20 shoot tips (approximately 5cm long). Collection of material started April 19 and continued to May 23, 2001. The dry material was examined for signs of disease, and any material that appeared diseased was incubated under moist conditions at room temperature for 24-48 hours. Microscopic examination was made of any infected areas observed on leaves, pedicels and shoots. The presence of *Entomosporium* spores on lesions was noted. The fruit was very dessicated and it was difficult to detect lesions. The ten sampled fruit were shaken in 10ml of water for several minutes, and three samples of the water were examined for spores.

Results And Discussion:

Entomosporium spores were first found on fruit from the Lynsley site on April 23 (Table 3.3.1.1). Spores were recovered from infected fruit from all sites, by May 15. Pedicels, attached and detached leaves were all infected with sporulating lesions. No spore production was observed on the shoots. Attached fruit from the previous season was the most prevalent source of overwintering inoculum. The Lynsley site developed the most overwintering inoculum, and this is likely because this site was a home garden where approximately 12 bushes were in close proximity to each other. The site was sheltered,

conducive to disease development, and no fungicide applications had been made in previous seasons.

Table 3.3.1.1. Production Of *Entomosporium* Spores In Spring 2001, From Different Types Of Plant Material Infected In The Previous Season.

Date Material Collected	Spore production on sites where material was collected: U of S	Riverbend	King	Lynsley
April 23				Fruit
30			fruit	Fruit
May 5	fruit			
7			fruit	detached leaves, fruit, pedicels
11	fruit			
14			fruit, pedicels	attached and detached leaves, fruit
15		fruit		
23				detached leaves

Summer conditions were generally dry in 2001, and leaf and berry spot was not a significant disease problem. However, rainy spells did occur later in the season, and leaf infections were observed at all sites in August/September. The over-wintering inoculum was capable of causing infection later in the season, despite the earlier dry conditions. Removal of infected material in the fall may significantly impact disease development in the following spring.

2002

Materials And Methods:

Over-wintering plant material was collected from seven sites in May 2002, and was examined for production of *Entomosporium* spores. The seven sites were: a) the Accession Orchard, University of Saskatchewan; b) the Cultivar Orchard, University of Saskatchewan; c) Riverbend Plantation; d) Last Mountain Berry Farm; e) J. Lynsley's garden, Outlook); f) Lormar Orchard; and g) South Valley Farm.

The material collected at random from saskatoon bushes at each collection time comprised 20 detached leaves from around the base of the bushes, 10 shoots with attached pedicels and fruit, and 20 attached leaves. Sampling began on May 7 and finished on May 29. The dry material was examined for signs of disease, and any material that appeared diseased was incubated under moist conditions at room temperature for 24-48 hours. Microscopic examination was made of any infected areas observed on leaves and pedicels. The presence of *Entomosporium* spores on lesions was noted. The fruit were very dessicated and it was difficult to detect lesions. The 10 fruit

clusters sampled were shaken in 10ml of water for several minutes, and three samples of the water were examined for spores.

Results And Discussion:

Entomosporium spores were first found on detached leaves collected from Last Mountain Berry Farm on May 7 (Table 3.3.1.2). Infected material was found at all sites except the Cultivar trial at the University of Saskatchewan. The lack of overwintering inoculum at this site was not surprising as no disease was present on these bushes in 2001. Attached fruit from the previous season was the most prevalent source of overwintering inoculum.

Early summer conditions were generally dry in 2002, and leaf and berry spot was not a significant disease problem. However, rainy spells did occur later in the season, and leaf infections were observed at all sites except the cultivar trial in August/September, 2002. Late season infections had also occurred in 2001. The diseased material produced late in the 2001 season was capable of overwintering and remaining dormant until the weather was conducive to disease development later in the season in 2002.

Table 3.3.1.2. Production Of *Entomosporium* Spores In Spring 2002, On Naturally Infected Saskatoon Plant Material Overwintering At Sites In Saskatchewan.

Collection site	Collection date	Plant material on which spores produced
Last Mountain Berry Farm	May 7	Detached leaves
Outlook Garden	May 8	Attached & detached leaves, fruit
Accession orchard	May 9	Attached leaves
Riverbend Plantation	May 15	Fruit
South Valley Farm	May 16	Attached & detached leaves, fruit
Accession orchard	May 27	Fruit
Riverbend Plantation	May 29	Attached & detached leaves, fruit

2003

In 2001 and 2002, over-wintering plant material was collected in early spring and was examined for production of *Entomosporium* spores. Spores were found on leaf and fruit material from almost all sites in both years.

Early summer conditions were generally dry in both years, and leaf and berry spot was not a significant disease problem. However, rainy spells did occur later in the season, and leaf infections were observed by August/September in both 2001 and 2002. The diseased material produced late in the season was capable of overwintering and remaining dormant until the weather was conducive to disease development.

Materials And Methods:

In 2003 attached and detached leaves collected in May from the Accession and Lormar orchards were examined for the presence of over-wintering *Entomosporium*.

Results And Discussion:

Entomosporium spores were produced on attached leaves collected from the Accession orchard on May 16, after several days' incubation. Attached and detached leaves collected from the Lormar site on May 22 also produced *Entomosporium* spores.

Spores of *E. mespili* were produced on over-wintering plant material collected in the spring from saskatoon bushes at different sites over a 3-year period. Thus disease inoculum is consistently produced on this kind of plant material, and it has the potential to initiate disease problems in the orchards every season, should suitable conditions occur.

3.3.2. Monitoring Of The Spore Production Of *E. mespili* In Saskatoon Bushes

Development of disease is conditional on the presence of disease inoculum, and the conditions suitable for infection to occur. Disease inoculum of *E. mespili* exists as the microscopic spores that are produced on acervuli and are spread in rain-splash. If the presence of spores could be monitored or predicted, growers could apply fungicides to inhibit infection and disease development. Monitoring of the occurrence of these spores was attempted in several ways in the Accession orchard, University of Saskatchewan.

2001

Materials And Methods:

Production of *Entomosporium* spores was monitored at the Accession orchard, from the end of May to mid-September, 2001. Twelve plastic bottles, with attached funnels, were wired onto stems in six saskatoon bushes. Two bottles per bush were attached within the bush canopy, in a vertical position, at heights of approximately 1.6m and 0.6m. A rain gauge close to the orchard recorded rainfall. After a rainy spell, the water collected in the bottles was removed, and a sample of the water examined microscopically for the presence of *Entomosporium* spores. Irrigation was applied twice, on June 8 and July 16. Samples were collected on 17 occasions, generally after light rainfall of 0.8mm or less.

Results And Discussion:

Entomosporium spores were found in water samples on three occasions. They were present in water samples collected on July 16 (after 0.5mm rain + irrigation), August 15 (0.3mm rain) and September 13 (0.4mm rain). The spores were observed in water collected from the upper region of the canopy in all instances. Disease developed in mid to late July in 2001, therefore the lack of spores observed until mid-July was not surprising. However, the incidence of spores collected was low, even when disease symptoms became apparent. This indicates that this spore sampling method may not be effective in monitoring spore production and/or movement.

2002

Materials And Methods:

Production of *Entomosporium* spores was monitored at the Accession orchard, University of Saskatchewan, using an automatic spore sampler, purchased from the University of Manitoba in 2002. The sampler consisted of a rotating drum holding a set of 24 test tubes that could be individually positioned underneath a funnel. The rainfall occurring in one hourly period was funneled into one tube, and the drum then rotated so that a second tube was in position under the funnel for the next hourly period. There were sufficient tubes for collection for a 24hour period. Tubes were then removed and a second set put in the sampler for the next 24hour period. The rainfall collected was examined under the microscope for presence of *E.mespili* spores. The sampler was installed under a saskatoon bush in mid-June and the rainfall samples were collected and monitored on a daily basis for the presence of spores until mid August.

Results And Discussion:

Entomosporium lesions were first noted in the Accession orchard on June 21. Several days later, sporulating lesions were found on leaves of suckers, and heavy infections were noted on the volunteer seedlings (at the 3 leaf stage) growing between the rows. Spores were only collected in the spore trap once, on August 8, after a heavy rainfall, despite the presence of sporulating lesions on leaves near the spore trap on June 23.

The spore sampler was not effective in detecting the spores responsible for early infections, as spores were not present in the water samples collected in the trap until well after lesions were observed on leaves.

3.3.3. Evaluation Of Fungicide Efficacy For Control Of *Entomosporium* Leaf And Berry Spot And Saskatoon-Juniper Rust

A number of fungicides are registered for the control of foliar and fruit pathogens of saskatoon, but the most effective and most frequently used is Topas 250E. This product (active ingredient propiconazole) is very effective in controlling both leaf and berry spot and rust infections, and the recommended spray schedule is for three applications to be made at white tip, petal drop and green fruit. However these stages can occur very

quickly and often producers will only have time to apply the product twice. The last application must be made 38 days prior to harvest, and this again reduces the window of opportunity for spraying. Unfortunately the fungicidal effect of Topas does not last for 38 days and producers frequently complain that significant *Entomosporium* infections develop on the fruit in the last week or so before harvest. The only chemical option available for control at this time is Kumulus (a sulphur product) that can be sprayed up to 24 hours before harvest. This product is protective only, and is not weather-fast. Hence producers may need to apply frequently if a rainy spell occurs before harvest. Repeated applications of Kumulus can result in bronzing and blackening of the leaves, as the product is toxic to the leaves.

Reliance on one product, such as Topas, is not a sound management practice, as pathogens may develop resistance to the product after repeated exposure. Evaluation of alternative products, in particular new chemistries becoming available, was conducted in trials at the University and Riverbend sites.

2001

Materials and Methods:

Evaluation of control of *Entomosporium* leaf and berry spot and saskatoon-juniper rust was conducted at two sites – the University of Saskatchewan, using two rows of Smoky bushes in the Cultivar Orchard, and the Riverbend Plantation, using a row of Thiessen bushes. Four products that had been previously tested in 1999 and 2000 were applied.

The pesticide treatments were applied as follows: a) control – no pesticides applied; b) Topas 250E (250 g/L propiconazole, Engage Agro Corp), applied at 4.5ml product in 3L water, plus Decis 5.0EC (50g/L deltamethrin, Hoescht Canada Inc.), applied at 0.5ml product in 3L water; and c) Sovran (a.i. kresoxim-methyl, BASF) applied at 1.4g in 3L water, plus Decis at same rate as treatment 2. Decis is an insecticide routinely applied by commercial growers for control of apple curculio, hawthorn weevil, saskatoon budmoth, Saskatoon sawfly and other insect pests.

One application of Decis was applied to the Topas and Sovran treated bushes at the end of April. Topas, Sovran and Dipel applications were made once, in the third week of May, when petals were falling, and fruit beginning to form. Only one application was made, because the late first application did not allow sufficient time for a second application of Topas, before the pre-harvest interval of 38 days.

At the Cultivar Orchard, two bushes of Smoky received each treatment, with at least one bush between treatments. The treatments were replicated four times, in two rows. At Riverbend Plantation, the treatments were applied to single large bushes, with at least 2m of row between treatments. These bushes had been sprayed with the same pesticides in 2000. Four replicate bushes were sprayed with each treatment, in a randomized order within a single row.

Disease assessments were made on samples taken approximately every two weeks, from June 7th until harvest in the first week of July. Twenty upper leaves and twenty lower leaves per treated bush(es) were sampled and disease incidence and severity were calculated. Disease assessment on 12 upper and 12 lower fruit clusters were taken before harvest, and the percentage of infected fruit per cluster was recorded.

Leaf samples were taken from the control, Sovran and Topas treated bushes on August 10-11th, and disease levels determined. An application of both fungicides was made at both sites on August 12th, to determine the effectiveness of these chemicals in reducing pathogen inoculum levels available for over-wintering. An evaluation of disease levels on the leaves was made on August 29th, approximately 2.5 weeks after spraying.

Results And Discussion:

Very low levels of disease had developed by harvest time in early July, at both sites. Insignificant levels of berry spot and rust were found on fruit sampled from both sites at harvest time. Yield data were not taken because of the low disease levels. The level of rust infections remained low, and evaluation of control of rust was not possible.

Disease levels of leaf spot on the leaves sampled in the second week of August were insignificant at the U of S, but at Riverbend Plantation, an average of 86% of leaves showed some *Entomosporium* infection (August 11, Table 3.3.3.1). The extremely low levels of disease at the U of S site were due not only to the dry summer conditions but also to the management of the orchard. The rows of bushes were separated by approximately 3 m of cultivated soil, and there was very little undercover growth. These factors allowed for considerable air movement around the bushes, which reduced humidity and provided conditions not conducive for disease development.

Table 3.3.3.1. Effect Of Fungicide Treatment On The Percentage *Entomosporium* Leaf Infection At Riverbend Plantation, 2001.

Treatment	Average % Leaves Infected					
	Sampled August 11			Sampled August 29		
	Upper leaves	Lower leaves	Average	Upper leaves	Lower leaves	Average
No chemical	80.0a*	92.5a	86.3a	68.8a	92.5a	80.6a
Topas	61.3a	65.0b	63.3b	78.8a	68.8ab	73.8a
Sovran	31.3b	16.3c	23.8c	28.8b	35.0b	31.9b

*means followed by the same letter within a column are not significantly different using the Duncan's Multiple Range test (P=0.05)

At Riverbend Plantation, the rows of large bushes were close together, and were in a sheltered location where humidity was generally high, providing conditions much more conducive to disease development. Levels of disease were lower on the Topas and Sovran treated bushes than on the unsprayed control bushes, with Sovran treated bushes having significantly lower disease levels than Topas treated bushes. These disease levels may

have reflected fungicidal activity from the spray application at the end of May, but are more likely the result of lower inoculum levels being present in the bushes that were treated with Sovran the previous year. Disease levels on leaves 2.5 weeks after spraying in August again showed that Sovran treated bushes had lower disease levels than Topas treated bushes, which were not significantly different than the control bushes. The percentage of leaf infection, and disease score was generally slightly higher on the lower leaf samples. The average of upper and lower leaf assessments, when analyzed, gave a similar response to the separate assessments in most cases, and could be used in future assessments.

Table 3.3.3.2. Effect Of Fungicide Treatment On *Entomosporium* Leaf Disease Infection Score At Riverbend Plantation, 2001.

	Average Disease Score					
	Sampled August 11			Sampled August 29		
Treatment	**Upper leaves**	**Lower leaves**	**Average**	**Upper leaves**	**Lower leaves**	**Average**
No chemical	0.9a*	1.0a	0.9a	1.0a	1.0a	1.0a
Topas	0.5ab	0.7b	0.6b	1.0a	1.0a	1.0a
Sovran	0.3b	0.2c	0.2c	0.3a	0.4a	0.3a

*means followed by the same letter within a column are not significantly different using the Duncan's Multiple Range test (P=0.05).

Disease scores were low, with the highest score of 1.0, meaning that only 1 to 5% of leaf area was infected. Leaf scores for Sovran-treated bushes were lower at the first sampling time (Table 3.3.3.2), again suggesting a lower inoculum level.

The reduction in disease levels in the fungicide treated bushes, before spraying in August, suggests that a regular spray program will reduce disease through the reduction in inoculum present before microclimate conditions conducive to disease occur. The value of a post-harvest spray in reducing inoculum for the next season will be investigated.

Results from previous trials indicated that Sovran would be a useful product for saskatoon producers. It is effective in reducing disease levels in the season of application, and may reduce long-term inoculum levels. It is also advantageous for growers to use fungicides with different chemistries to reduce the risk of fungicide resistance developing in pathogens. Minor use registration of Sovran should be considered.

2002

Materials And Methods:

Three trials for the evaluation of control of *Entomosporium* leaf and berry spot and saskatoon-juniper rust were conducted at the University of Saskatchewan (Cultivar and Accession Orchards), and the Riverbend Plantation. The efficacy of two unregistered products was compared with that of Topas, the fungicide currently used by the industry.

The fungicides were applied at two times: petal drop which occurred at the beginning of June, and green fruit which occurred two weeks later. As harvest occurred in mid-July this second application would not meet the required pre-harvest interval of 38 days for Topas application.

The six pesticide treatments were as follows: a) control, no pesticides applied; b) two applications of BAS 516 (boscalid & pyraclostrobin, BASF), 2.4gm product in 3L water at petal drop and green fruit stage (516 X 2); c) Topas 250E (250 g/L propiconazole, Engage Agro Corp), 1.9ml product in 3L water applied at petal drop followed by Sovran (kresoxim-methyl, BASF), 1.4g product in 3L water applied at green fruit stage (T+S); d) two applications of Sovran (S+S); e) two applications of Topas (T+T); f) one application of Sovran followed by one application of Topas (S+T). The rates were calculated on a per bush basis (assuming a planting density of 850 bushes per acre).

At the Cultivar Orchard, two bushes of the cultivar Smoky received each treatment, with at least one bush between treatments. The treatments were replicated four times within three rows. Similarly, at the Accession Orchard, two bushes received each treatment, with at least one bush between treatments. The treatments were replicated four times, in 2.5 rows. At Riverbend Plantation, the treatments were applied to single large Thiessen bushes, with at least 2m of row between treatments. The treatments were replicated four times within two rows.

Disease assessments were made on 20 leaf samples taken approximately every two weeks from the end of June until mid August.

Results And Discussion:

Disease levels of leaf and berry spot were extremely low in all three trials throughout the season. The efficacy of fungicide treatment for control of this disease could not be determined. However, natural infection by the rust pathogen, *Gymnosporangium* sp. was appreciable. Levels of rust infection were measured at all three trials, and significant effects of fungicide treatments were observed for two sampling times at the University sites, and for three sampling times at Riverbend Plantation.

The percentage of leaves infected with rust was highest on the unsprayed, control bushes at all sites (Table 3.3.3.3). At the Accession Orchard two applications of Sovran did not significantly reduce rust levels. All other fungicide treatments containing one or two applications of Topas and two applications of BAS 516 significantly reduced rust infection at this site. At the Cultivar Orchard in July, all fungicide treatments, including the two applications of Sovran, reduced rust levels. By August all other fungicide applications were more effective than Sovran in reducing rust. The earliest assessment at Riverbend showed no significant differences between treatments but by July 16 and August 14 all fungicide treatments had significantly reduced the percentage of leaves infected with rust. At Riverbend the Sovran applications were as effective as the other fungicide treatments for all sampling dates.

Table 3.3.3.3. Effect Of Fungicide Application On Percentage Of Leaves Infected With Saskatoon-juniper Rust, At Three Trials, July-August 2003.

Fungicide treatment	Average % leaves infected with rust at:						
	Accession July 15	Accession August 7	Cultivar July 15	Cultivar August 9	Riverbend July 3	Riverbend July 16	Riverbend August 14
Control	23.8 a[1]	36.3 a	43.8 a	50.0 a	7.5 a	13.8 a	31.3 a
BAS[2] X 2	1.3 b	10.0 b	3.8 b	0 c	2.5 a	2.5 b	7.5 b
T[3] + S[4]	1.3 b	5.0 bc	3.8 b	1.3 c	6.3 a	3.8 ab	6.3 b
S + S	17.5 a	30.0 a	2.5 b	16.3 b	2.5 a	2.5 b	2.5 b
T + T	0 b	0 c	0 b	0 c	1.3 a	1.3 b	0 b
S + T	0 b	0 c	1.3 b	0 c	0 a	0 b	1.3 b

[1] means followed by the same letter within a column are not significantly different using the Duncan's Multiple Range test (P=0.05).
[2] BAS 516 applied twice
[3] Topas 250E
[4] Sovran

At almost all assessments the fungicide treated bushes were considerably less diseased than the unsprayed bushes.

2003

Materials And Methods:

Trials for the evaluation of control of *Entomosporium* leaf and berry spot and saskatoon-juniper rust were conducted at the Cultivar and Accession Orchards at the University of Saskatchewan. The efficacy of one unregistered fungicide (BAS 516), and two unregistered organic type products (FungiNeem and Melaleuca oil) was compared with that of Topas, the fungicide currently used by the industry. The BAS product was a combination of boscalid, which received registration as Lance in 2004 and pyraclostrobin, which was registered as Cabrio in 2003. The BASF company anticipates registering the mixture in the next year and if the efficacy data is acceptable then application for Minor Use or Label Expansion could be made. Melaleuca oil (produced by the Australian Tea Tree, *Melaleauca alternifolia*) has been advertised as a broad spectrum disinfectant for use medicinally and as a cleaning agent. Data supplied by the Tea Tree Oil Growers of Australia, Main Camp Tea Tree Oil Group, (http://www.avreskincare.com/teatreeoil/teatreeoil_ extracts.html) show that the oil can inhibit growth of certain bacteria and fungi. Thus it has the potential to act as a fungicide, and may be an acceptable product for organic growers. Similarly FungiNeem has been shown to have fungicidal properties (personal communication Marcel Brossard, Pronatex Inc.) and may be an acceptable product for organic growers.

The five chemical treatments were as follows: a) control, no pesticides applied; b) two applications of Topas 250E (250 g/L propiconazole, Engage Agro Corp), 1.9ml product in 3L water; c) two applications of BAS 516 (boscalid & pyraclostrobin, BASF), 2.4gm product in 3L water; d) one application of FungiNeem (potassium salts of fatty acids

from Neem oil, Pronatex Inc.), 75ml product in 3L water; e) three applications of Melaleuca Oil (T36-C5 Melaleuca Oil, Melaleuca Sales Co.), 15ml in 3L water applied. The rates were calculated on a per bush basis (assuming a planting density of 850 bushes per acre).

Topas, BAS 516 and Melalueca oil were applied twice, on May 8 (at white tip), and on June 10 (at green fruit in Accession Orchard, fruit turning pink in Pembina cultivar). FungiNeem was only applied on June 10, and a third application of Melaleuca oil was made on June 30, approximately two weeks before harvest.

At the Cultivar Orchard, one bush of the cultivar Pembina received each treatment, with at least one bush between treatments. The treatments were replicated four times within two rows. At the Accession Orchard, two bushes of the Good Spirit Lake genotype received each treatment, with at least one bush between treatments. The treatments were replicated four times, in two rows. Two bushes in the Accession Orchard were approximately equal in surface area to one Pembina bush.

Disease assessments were made on 20 leaf samples taken twice in June and once a month in July and August. Fruit assessments were done on clusters collected at the end of July.

Results and Discussion:

Disease levels of leaf and berry spot were low throughout the season, but significant differences in the percentage of leaves infected were observed in the Accession Orchard in July, and in both orchards by August (Table 3.3.3.4). Applications of Topas and BAS 516 consistently reduced disease levels when compared with the bushes sprayed with FungiNeem. However the values for the fungicide sprayed bushes were not significantly different than the values for the unsprayed control bushes. The data indicate that treatment with FungiNeem appeared to increase disease levels, possibly due to phytotoxicity. FungiNeem was only applied once, on June 10, as by June 25 blackening of the leaves was evident, and this was considered to be a phytotoxic reaction, similar to that shown when sulphur is applied to saskatoons. FungiNeem was applied as a 2.5% solution and subsequent discussion with the supplier (Marcel Brosseau, Pronatex Inc.) revealed that phytotoxicity had been reported previously when concentrations over 2% were applied.

Extremely low levels of saskatoon-juniper rust were observed in 2003. No significant differences occurred between treatments.

In mid May an outbreak of *Monilinia* infection was observed in the chokecherry orchard at the University site. *Monilinia amelanchieris* is the cause of brown fruit rot (mummyberry) of saskatoon, and this disease was also noted in the Accession Orchard. Assessment of the percentage of fruit infected in a sample of ten clusters of fruit taken from each treated bush showed that the application of Topas on May 8 significantly reduced the level of disease. BAS 516 also reduced disease levels, but not as effectively as Topas (Table 3.3.3.5). The application of Melaleuca oil did not affect disease levels

when compared with the untreated control bushes. By the end of July there were no significant differences in the level of brown fruit rot observed in the Accession Orchard,

Table 3.3.3.4. Effect Of Chemical Application On Percentage Of Saskatoon Leaves Infected With *Entomosporium*, In The Accession And Cultivar Orchard Trials, July-August 2003.

Treatment	Av. % leaves infected with Entomosporium (n=20)		
	Accession orchard		Cultivar orchard
	Rated July 29	Rated Aug 12	Rated Aug 12
Control	8.7 ab*	23.7 ab	1.2 ab
Topas [xy]	0.0 a	3.7 a	0.0 a
BAS 516 [xy]	0.0 a	1.2 a	0.0 a
Melaleuca oil [xyz]	11.2 ab	20.0 ab	12.5 bc
FungiNeem [y]	15.0 b	33.7 b	16.2 c

* means followed by the same letter within a column are not significantly different using the LSD test (P=0.05).

[x] chemical applied May 8; [y] chemical applied June 10; [z] chemical applied June 30.

although the percentage of infected fruit in a 20 cluster sample was twice as high from the control bushes compared with the fruit collected from the bushes that had been treated with Topas and BAS 516. There were also significantly higher numbers of fruit produced on the Topas and BAS 516 bushes, when compared with all other treatments (Table 3.3.3.5).

Table 3.3.3.5. Effect Of Chemical Application On Fruit Production And Levels Of Brown Rot Of Saskatoon, In The Accession Orchard Trial, 2003.

Treatment	Av. % of fruit with brown rot		Total # of fruit in 20 clusters
	May 27 (10 fruit clusters)	July 24 (20 fruit clusters)	
Control	48.4 a	14.1 a	78.5 a
Topas [xy]	14.8 c	5.7 a	123.7 c
BAS 516 [xy]	33.1 b	6.1 a	105.0 b
Melaleuca oil [xyz]	42.4 ab	8.9 a	88.5 a
FungiNeem [y]	Not assessed	9.7 a	90.1 ab

* means followed by the same letter within a column are not significantly different using the LSD test (P=0.05).

[x] chemical applied May 8; [y] chemical applied June 10; [z] chemical applied June 30.

Rust infection levels were very low in 2003 and it was not possible to assess the efficacy of treatments for control of rust.

2004

Materials And Methods:

Two identical trials were conducted at the University of Saskatchewan in 2004, in the Accession Orchard and in the Cultivar Orchard. In the Accession Orchard, two bushes of the East Shoal Lake genotype received each treatment, with at least one bush between treatments. In the Cultivar Orchard, one bush of the cultivar, Smoky, received each treatment, with at least one bush between treatments. The treatments were replicated four times within two rows at both sites. Two bushes in the Accession Orchard were approximately equal in surface area to one Smoky bush.

The four treatments were as follows: a) control, no pesticides applied; b) two applications of Topas 250E (250 g/L propiconazole, Engage Agro Corp), 1.9ml product in 3L water; c) two applications of BAS 516 (boscalid & pyraclostrobin, BASF), 2.4gm product in 3L water; d) two applications of FungiNeem (potassium salts of fatty acids from Neem oil, Pronatex Inc.), 30ml product in 3L water. The rates were calculated on a per bush basis (assuming a planting density of 850 bushes per acre).

The first application was made on May 23, when the bushes were at balloon to full flower growth stage and the second application was made on June 8, when the bushes were at the green fruit stage.

Disease assessments were made on 40 leaf samples taken twice in June and once in early July (prior to harvest). Fruit assessments were done on 20-cluster samples collected at the beginning of August.

Results And Discussion:

On May 30, rust galls were noted in the Patterson garden, adjacent to the Horticulture field. The galls were at the jelly stage (Figure 3.1.3), and were releasing spores. *Entomosporium* lesions were first observed on leaves and fruit in the Accession Orchard on July 6. The leaf samples taken in June had no symptoms of *Entomosporium*. By mid-June very low levels of rust infection were noted in two unsprayed treatments in the Accession Orchard. Significant levels of *Entomosporium* leaf infection were present in both trials by July 6 and significant levels of disease had developed on the fruit by early August. There were low levels of rust infection in both trials, which was surprising as generally high levels of disease were observed in Saskatchewan in 2004.

Topas and Bas 516 consistently reduced the incidence of leaves and fruit infected with *Entomopsorium* in the Accession Orchard (Table 3.3.3.6). Neem did not control the disease, and actually increased the incidence of *Entomosporium* in July. No rust infection was observed on the Topas treated leaves, and the incidence of infection was reduced by application of BAS 516. However BAS 516 was not as effective in controlling rust as Topas. The incidence of berry spot was significantly lower on bushes treated with both Topas and BAS 516. Both fungicides had continued to protect the fruit from infection, over the 58-day period since the last spray. The efficacy of protection during the pre-

Table 3.3.3.6. Evaluation Of Fungicidal Control Of Saskatoon Diseases Of Leaves And Fruit, Accession Orchard 2004.

Fungicide applied	Average incidence of leaf infection (%) on July 6, for:		Average incidence of fruit infection (%) on August 5
	Entomosporium	Rust	*Entomosporium*
Control	9.4 b*	5.6 a	43.7 a
Topas	3.1 c	0.0 b	10.9 b
Bas 516	1.3 c	3.8 ab	7.5 b
Neem	17.5 a	8.1 a	57.4 a

* means followed by the same letter within a column are not significantly different using the LSD test (P=0.1)

harvest period would depend on the timing of infection. When infection was initiated soon after fungicide application, fruit would be protected, but if infection was initiated 4-5 weeks after application, fruit would not be well protected.

Disease levels were lower in the Cultivar Orchard, an observation that has been made in previous years. There were no significant differences in the incidence of *Entomosporium* infected leaves in July, but in August the incidence of infected fruit was significantly lower on the bushes treated with both Topas and BAS 516 (Table 3.3.3.7).

Table 3.3.3.7. Evaluation Of Fungicidal Control Of Saskatoon Diseases Of Leaves And Fruit, Cultivar Orchard 2004.

Fungicide applied	Average incidence of leaf infection (%) on July 6, for:		Average incidence of fruit infection (%) on August 4
	Entomosporium	Rust	*Entomosporium*
Control	4.4 a*	8.1 a	2.3 a
Topas	2.5 a	0.0 b	0.2 b
BAS 516	1.3 a	3.1 ab	0.0 b
Neem	3.8 a	4.4 ab	1.3 ab

* means followed by the same letter within a column are not significantly different using the LSD test (P=0.1)

No rust was observed on the Topas treated bushes, and although the level of diseases was low on the BAS 516 treated bushes it was not significantly lower than on the untreated control bushes. BAS 516 was not as effective as Topas in controlling rust infection. Neem did not significantly reduce the levels of either disease.

3.3.4. Influence Of Pruning On Disease Development In Saskatoons

Maintenance of the saskatoon orchard includes regular pruning of bushes to remove any damaged and diseased branches. In mature orchards it is also necessary to remove the older stems that become too tall for picking either mechanically or by hand. Thinning of the plant material in the row allows greater airflow between and through bushes. This reduces the humidity within the row and may create conditions less favourable for disease development. Growers have observed that maintaining a more open orchard appears to reduce disease levels. Consequently, removal of a certain percentage of stem material may be an ideal IPM strategy. The possibility of using pruning as a disease control technique was evaluated at three sites over a three-year period.

2001

Materials And Methods:

The pruning trials were conducted at Riverbend Plantation and Last Mountain Berry Farm. Both sites were established orchards, with 7-year old Northline bushes that had not been pruned extensively in the last few years.

At Riverbend Plantation, one row of bushes was used, and at Last Mountain Berry Farm, two rows. Selected areas in the rows were pruned to 1/3 or 2/3 of the existing stand, and a control treatment of unpruned bushes was included (Figures 3.3.4.1 through 5). Two bushes, approximately 2m in row length, were pruned for each density, with at least one bush (1m) between treatments. The treatments were replicated four times. The two sites were pruned in April 2001. No fungicides were applied, but the treatment rows were sprayed with insecticide by the co-operators using standard orchard practices.

Disease development was monitored throughout the season. At harvest, the total and marketable yield per treated area was recorded, and the average weight of a 10- fruit sample was taken.

Results And Discussion:

At Riverbend Plantation, there was a significant effect of pruning on the total yield of the bushes (Table 3.3.4.1). Both pruning treatments significantly reduced the yield from the 2m length of row, but there was no difference in yield between the two pruning levels. There was no effect of pruning on the quality of fruit produced; the percentage of marketable fruit and the 10-fruit weight were not affected by pruning.

At Last Mountain Berry Farm, there were no significant differences between any of the treatments (Table 3.3.4.1). The pruned bushes produced as much as the unpruned bushes. In one replicate, for each of the pruning treatments, there was a gap between bushes that allowed for a greater fruit production from that section. However, when these values were removed, and the average of three (rather than four) replicates was used,

Table 3.3.4.1. Effect Of Pruning On Total Yield Of Fruit At Riverbend Plantation, 2001.

Pruning Treatment	Total Yield (kg)	
	Riverbend	Last Mountain
No pruning	8.4 a*	6.8a
1/3 removed	6.5 b	7.3a
2/3 removed	6.0 b	7.7a

* means followed by the same letter withn a column are not significantly different using the Duncan's Multiple Range test(P=0.05).

there was still no difference between the treatments. The yield values at Last Mountain Berry Farm were comparable to the pruned values at Riverbend Plantation.

Insignificant levels of disease developed on leaves and fruit at both sites. A final assessment of leaf disease was carried out at the end of August. By this time over 90% of the leaves were infected by *E. mespili* at Last Mountain Berry Farm, but levels at Riverbend Plantation remained low (Table 3.3.4.2). Frequent showers at Last Mountain Berry Farm contributed to the disease development at this site.

Table 3.3.4.2. Levels Of *Entomosporium* On Leaves At Two Pruning Trials At The End Of August, 2001.

Pruning Treatment	Average % Leaves Infected*		Average Disease Score*	
	Riverbend	Last Mountain	Riverbend	Last Mountain
No pruning	5.6	94.4	0.0	1.2
1/3 removed	10.6	97.5	0.1	1.5
2/3 removed	14.4	94.4	0.1	1.6

* no significant differences using the Duncan's Multiple Range test(P=0.05).

There was no significant effect of pruning treatment on disease levels on the bushes at either site. It is possible that the length of each pruning treatment was not long enough to significantly alter the microclimate in the row.

2002

The collection of disease development and yield data was continued at the pruning trials established in spring 2001 at Riverbend Plantation and Last Mountain Berry Farm. The three pruning treatments established in 2001 were: 1) no pruning; 2) 1/3 plant material pruned out (standard pruning recommendation); and 3) 2/3 plant material pruned out. The previously pruned areas at both sites were pruned lightly in the first week of May 2002, to remove some of the new growth that was produced as a result of the previous year's pruning. Approximately one third of the new growth was left in the areas that were most heavily pruned areas, two thirds were left in the less pruned areas and no pruning was done in the unpruned areas.

Three new pruning trials were established in fall 2001 or spring 2002 at three locations, Last Mountain Berry Farm, Lormar Orchard and the Acession Orchard at the University of Saskatchewan. At Last Mountain Berry Farm, on October 26, 2001, a second pruning

trial was established in a block of 12- year old Smoky bushes that had never been pruned. The bushes were very tall, over 3.5 m, (Figure 3.3.4.6) and could not be machine-picked because of their size. The rows were planted 5 m apart but the bushes had grown out to approximately 2m apart with cultivated soil between them. There was restricted airflow through the bushes, which were located in a low-lying area, and leaf and berry spot had been observed by the grower when weather conditions were favourable for disease. Ten metre lengths of row were pruned to 1/3 or 2/3 of the existing stand, or left unpruned for a control treatment. The treatments were replicated three times, and the trial was duplicated so that one set of treatments could be sprayed with fungicides by the grower if necessary, and the other set of treatments remained unsprayed. This would allow a comparison of the impact of pruning on the bushes with and without fungicidal control of disease. All bushes were sprayed with the insecticide, Decis using recommended rates and timing.

The trial at Lormar Orchard was pruned on May 2, 2002. Six metre sections of row in a 6 year old planting of Pembina bushes were pruned to 1/3 or 2/3 of the original plant stand, or left unpruned. The rows were widely spaced (planted 6m apart) with grass planted between them. The three treatments were replicated four times, using two rows of bushes. Decis was applied once, to control apple curculio and sawfly.

The trial at the Accession Orchard was pruned on May 9, 2002. Five metre sections of row in a mature planting were subjected to: 1) severe pruning by removal of 2/3 of the plant material; 2) standard pruning by removal of 1/3 of the plant material; and 3) very light pruning by removal of branches that impeded row access. The bushes were approximately 2m high and the rows were originally planted 1.8m apart. Suckers were allowed to grow in the intervening space until mid-season, when they were removed with a weedwhacker. No chemicals were applied to this site.

Disease development was monitored throughout the season. The incidence of both leaf and berry spot and rust was assessed before and after harvest. At harvest, the total yield of fruit/metre of treated area was recorded, and the average weight of a 10-fruit sample was taken at several of the sites.

Weather monitoring equipment was installed at the accession orchard trial in the beginning of June. The data loggers recorded relative humidity, air temperature and leaf wetness on an hourly basis at 1 metre height. One data logger was installed in each of the three treatments. Data was downloaded from the loggers on the 21st of September.

Results And Discussion:

Pruning treatments significantly affected disease levels at the Lormar and Accession sites, where the disease pressure was higher than at the Riverbend and Last Mountain Berry Farm sites.

Riverbend site (pruned spring 2001):

Disease development was monitored at this site, one year after pruning was carried out. Leaf samples were collected on July 3 (40 leaves per treatment), August 26 (30 leaves per treatment) and September 2 (20 leaves per treatment from upper half of bushes, 20 from lower half of bushes), 2002. In July there were no *Entomosporium* lesions present and less than 2% of the leaves were infected with rust. By August 26th there were still no *Entomosporium* lesions present but the rust levels had increased to an average of 6.4% infected leaves. However there were no significant differences in the rust levels among the three pruning treatments. Low levels of *Entomosporium* lesions were present on the lower leaves by September 2 (an average of 8% of leaves were infected), but there were no significant differences in the levels of disease.

There were no significant differences in the yield/metre of the pruned areas, although the most heavily pruned sections had significantly smaller berries than the other two treatments (Table 3.3.4.3). This may be due to increased flowering on the new growth produced the year after heavy pruning, resulting in more, smaller berries. The overall yield was not affected, indicating that the bushes quickly recovered from the removal of the larger stems pruned out in the previous season.

Table 3.3.4.3. Effect Of Previous Year's Pruning On Average Fruit Weight Of Saskatoons, Riverbend Site 2002.

Pruning treatment in 2001	Average weight of 10 fruit harvested in 2002
None	8.8 a*
1/3 removed	8.5 a
2/3 removed	7.8 b

*means followed by the same letter within a column are not significantly different using the Duncan's Multiple Range test (P=0.05).

Last Mountain site (pruned spring 2001):
At the first trial at the Last Mountain site, which was pruned in spring 2001, 20 leaves were sampled on June 24 and August 21. No disease was present in June, and an average of 16% of the leaves were infected with *Entomosporium* by the second sampling date. There were no significant differences in disease level or yield among the three pruning treatments. No rust infection was observed at this site.

The similarity in results from the Riverbend and the Last Mountain trials initiated in spring 2001 suggests that either: 1) disease levels were too low to demonstrate pruning effects; or 2) pruning has no influence on the disease level in the second season after the pruning; or 3) the length of row pruned in these trials was too small to influence disease development. The three new trials reported here used longer lengths of row for each treatment to overcome the third possibility.

The lack of impact of pruning in 2001 on fruit yield in 2002 might also have been caused by the small length of row pruned. It is also possible that the bushes produced sufficient

flowers and fruit on the growth initiated in 2001 after pruning to cause a rapid recovery in yield. Similarly, a surprisingly small impact of pruning on yield occurred in 2001.

Last Mountain site (pruned fall 2001):
At the second trial at the Last Mountain site, which was pruned in the fall of 2001, *Entomosporium* infection was not observed until the August sampling. This trial was designed so that one set of replicated treatments was not sprayed with fungicide (NS) and a second set of replicated treatments could be sprayed with a fungicide (SP) if the grower felt it was necessary. However, because of the low disease pressure in 2002, the SP rows were not sprayed. An average of 6% of the leaves in the SP rows and 12% of the leaves in the NS rows were infected by August 21. The greater infection levels in the NS rows were likely due to the fact that these rows were on the edge of the orchard in a low-lying, more humid area, which was frequently more susceptible to disease. There were no significant differences in the levels of disease between the three pruning treatments but in all cases the unpruned areas developed the most infection. The carry-over of disease in 2003 will be monitored.

Lormar site (pruned spring 2002):
No leaf and berry spot lesions were observed at the Lormar site in June, and very low levels of rust infection occurred throughout the summer at this site. On August 19 a significantly higher percentage of the 40 leaves sampled were diseased in the unpruned treatments (Table 3.3.4.4). On September 6, 20 leaves were sampled from the lower branches of the bushes and 20 from the upper branches. On this date there were significantly more infected leaves in the unpruned areas for both upper and lower leaves (Table 3.3.4.4). The average disease severity was higher on the lower (average disease score of 3.2) than the upper leaves (average disease score of 2.3), but there were no differences among pruning treatments.

Table 3.3.4.4. Effect Of Pruning On Disease Incidence Of *Entomopsorium* Leaf And Berry Spot At Two Sampling Times, Lormar Site, 2002.

Pruning treatment in 2002	Average % infected leaves on:		
	August 19	Sept. 6 (upper)	Sept. 6 (lower)
None	21.9 a*	63.8 a	98.8 a
1/3 removed	16.3 ab	50.0 b	91.3 b
2/3 removed	14.4 b	37.5 b	81.3 c

*means followed by the same letter within a column are not significantly different using the Duncan's Multiple Range test (P=0.05).

Fruit yield did not differ significantly among pruning treatments, but the 10-fruit weight was higher in the heavily pruned areas (Table 3.3.4.5). The plant material removed also contained flower buds for fruit production that year. Removal of these flower buds resulted in fewer, but larger fruit being produced. Whereas in the year following pruning at Riverbend, the fruit weight was lower in the treatments that had been most heavily pruned. More but smaller fruit were produced that year as flower buds for this fruit were set following pruning, and had not been removed.

University of Saskatchewan site (pruned spring 2002):
Leaf samples were taken in June, August and September at the Accession Orchard site.Significantly lower levels of rust were observed in the unpruned treatments in June (Table 3.3.4.6) but in the later assessments there were no significant differences between treatments. The higher disease levels observed in the pruned treatments in the June sampling were possibly due to the increased production of young leaves on new growth, which appeared to be more susceptible to rust infection. The incidence of fruit infection was not monitored in 2002 but this factor will be examined in 2003 as it is the fruit

Table 3.3.4.5. Effect Of Pruning On Average Fruit Weight Of Saskatoons, Lormar Site 2002.

Pruning treatment in 2002	Average weight of 10 fruit harvested in 2002
None	7.0 a*
1/3 removed	7.1 a
2/3 removed	8.4 b

*means followed by the same letter within a column are not significantly different using the Duncan's Multiple Range test (P=0.05).

infections that cause yield reduction by rust.

Table 3.3.4.6. Effect Of Pruning On Incidence Of Rust Infection Of Saskatoon Leaves, University Of Saskatchewan Site, 2002.

Pruning treatment	Average % infected leaves (40 leaf sample) on:	
in 2002	June 27	August 15
None	6.3 a*	25.0 a
1/3 removed	17.5 b	33.1 a
2/3 removed	13.8 b	31.9 a

*means followed by the same letter within a column are not significantly different using the Duncan's Multiple Range test (P=0.05).

Entomosporium disease did not develop until late in the season at this site. On September 3, 20 lower and 20 upper leaves were examined for incidence of disease. Five percent or less of the upper leaves were infected. The infection on the upper leaves did not differ significantly among the pruning treatments. However, the most heavily pruned bushes had significantly fewer lower leaves infected than those less pruned (Table 3.3.4.7). These bushes were more densely planted than recommended for a commercial orchard and the airflow was quite restricted. Heavy pruning appreciably increased the openness of the bushes. The resulting decrease in disease may have been due to the reduction in conditions favourable for disease. However, measurements of relative humidity recorded by the data loggers did not reveal appreciable differences in the humidity levels for the three pruning treatments (Figures 3.3.4.7, 3.3.4.8 and 3.3.4.9). No major differences in leaf wetness were recorded between the two pruning treatments in August (Figures 3.3.4.10 and 3.3.4.11). Unfortunately leaf wetness data in the unpruned treatment was not

available for August due to malfunction of the data logger. Thus, the weather data collected did not account for the significant difference in disease symptoms present in early September.

Table 3.3.4.7. Effect Of Pruning On Incidence Of *Entomosporium* Infection Of Saskatoon Leaves, University Of Saskatchewan site, 2002.

Pruning treatment in 2002	Average % infected leaves on: Sept. 6 (20 upper)	Sept. 6 (20 lower)
None	2.5 a*	10.0 ab
1/3 removed	5.0 a	12.5 a
2/3 removed	5.0 a	3.8 b

*means followed by the same letter within a column are not significantly different using the Duncan's Multiple Range test (P=0.05).

2003

The collection of disease development and yield data was continued at the pruning trials established in spring 2002 at Lormar Orchard and the Accession Orchard, University of Saskatchewan. No further pruning was undertaken in spring 2003.

The pruning trial established at Last Mountain Berry Farm in the fall of 2001 was no longer available for data collection as the site had been re-pruned by the grower.

The Lormar Orchard trial had been initially pruned on May 2, 2002. Six metre sections of row in a six year old planting of Pembina bushes were pruned to 1/3 or 2/3 of the original plant stand, or left unpruned. The three treatments were replicated four times, using two rows of bushes. Decis was applied twice in spring 2003, to control bud moth, apple curculio and sawfly.

The trial at the Accession Orchard was initially pruned on May 9, 2002. Five metre sections of row in a 13 year old planting were subjected to: 1) severe pruning by removal of 2/3 of the plant material; 2) standard pruning by removal of 1/3 of the plant material; and 3) very light pruning by removal of branches that impeded row access. No chemicals were applied to this site.

Disease development was monitored throughout the 2003 season. The incidence of both leaf and berry spot and rust was assessed before and after harvest. At harvest, the total yield of fruit/metre of treated area was recorded, and the average weight of a 10-fruit sample was taken at the Lormar site. The amount of insect damage was also monitored, as insect populations may be affected by bush density.

Results And Discussion:

Pruning treatments initiated in 2002 did not significantly affect the levels of leaf and berry spot at the Lormar and Accession sites in 2003. Yield data collected at harvest at the Lormar Orchard showed that the 1/3 pruned bushes produced a significantly greater yield of fruit than the unpruned bushes (Table 3.3.4.8), demonstrating the beneficial effect of pruning at the recommended level. The 10-fruit weights were not affected by the pruning treatments. There were also more insect damaged fruit produced on the unpruned bushes (4.6% of 300 fruit) compared with the 2/3 pruned bushes (1.3% of 300 fruit). The insect damage on leaves was not consistently different on the different treatments throughout the season.

Table 3.3.4.8. Effect Of Previous Year's Pruning On Yield And Insect Damage Of Saskatoon Fruit At Lormar Site, 2003.

Pruning treatment in 2002	Average weight of 10 fruit (gm)	Av. weight of fruit harvested/1m of row (kg)	# of insect damaged fruit (sample of 300)
None	6.4 a*	1.3 a	13.7 a
1/3 removed	6.7 a	1.9 b	6.0 ab
2/3 removed	6.2 a	1.6 ab	4.0 b

*means followed by the same letter within a column are not significantly different using the LSD test (P=0.05).

Pruning in 2002 had no effect on the levels of disease or insect damage in the Accession trial in 2003. Levels of leaf and berry spot were low until mid-August, by which time approximately 25% of the leaves were infected. Yield data were not taken, except for number of fruit produced in 20 clusters, and there were no significant differences in fruit number.

Very low levels of saskatoon-juniper rust occurred at both locations. There was no observable impact of pruning on disease in 2003.

3.3.5. Evaluation Of Mulching As A Method For Controlling Disease and Insect Damage To Saskatoons.

Previous observations (section 3.3.1) have shown that over-wintering inoculum of *E.mespili* is produced on leaves and fruit attached to saskatoon bushes, and also on detached leaves that remain under the bushes. If the fallen material was covered with a layer of mulch this might reduce the ability of spores to reach the new vegetation, and thus reduce infection by *E. mespili*. A layer of mulch might also impede the emergence of insects that over-winter in the leaf debris, and delay the laying of insect eggs on the upper parts of the bushes. Apple curculio and hawthorn lacebug are both insects that over-winter as adults in leaf litter, and emerge in the spring to lay eggs in fruit and on leaves, respectively. Rust spores are produced on galls on juniper bushes, and are windborne to the leaves and fruit of the Saskatoon bushes. Mulching under the bushes would not be likely to impact rust infection.

A preliminary trial to determine if disease levels and insect damage could be reduced by covering all detached leaves with a layer of mulch was initiated at the Lormar site in spring 2003. In 2004, three mulching trials were conducted, one at Lormar Orchard and two at Riverbend Plantation.

2003

Materials And Methods:

The ground under four metre lengths of row was covered with wood shavings to a depth of approximately 5cm (Figure 3.3.5.1). A similar length of non- mulched row was left beside the treated section. The treatments were replicated three times, twice with Smoky bushes and once with Thiessen bushes, in one row. The small amount of overwintering fruit and leaves remaining on the bushes in the mulched areas were removed, but this material was left on the unmulched areas.

On May 22nd attached and detached leaves from the previous season were collected from beside an unmulched area, and examined for the presence of sporulating *Entomosporium* lesions.

Samples of 20 fresh leaves were collected from the mulched and unmulched areas every month from June to September. The percentage of leaves with disease and insect damage were evaluated. Disease levels were low in this trial until August, by which time approximately 50% of the leaves were infected with *E.mespili*. In August 20 leaf samples were taken from the lower 1m of bush and 20 leaf samples were taken from the upper 1m, to determine if mulching affected the development of disease at the upper and lower levels. By the September sampling all leaves were infected with leaf and berry spot, and severity rather than incidence of disease was evaluated

Results And Discussion:

Disease development occurred after harvest. By the August sampling approximately 50% of the leaves were infected. By the September sampling all leaves were infected with leaf and berry spot. There were no significant differences in levels of disease but the mulched areas consistently had fewer diseased leaves in August and a lower severity of disease in September (Table 3.3.5.1) Similarly there were fewer insect damaged leaves on the bushes that had been mulched, in June, July and August, and in July this difference was significant (Table 3.3.5.2). It is possible that the higher levels of disease that occurred in the unmulched areas were influenced by the attached leaf and fruit material left on these bushes, whereas similar material was removed from the unmulched areas. In order to determine the role of attached versus detached material, in future mulching trials separate areas will be left with and without the attached fruit and leaves.

Table 3.3. 5.1. Effect Of Mulching On Development Of *Entomosporium* Infection Of Saskatoon Leaves At Lormar Site, 2003.

Treatment	Av. % infected leaves on August 14		Av. Severity of infection (20 leaves) in September
	Upper leaves (20)	Lower leaves (20)	
No mulch	36.7*	68.3	2.4
Mulch applied	30	50	1.8

*no significant differences between treatments using the LSD test (P=0.05)

Table 3.3.5.2. Effect Of Mulching On Incidence Of Insect Damage Of Saskatoon Leaves At Lormar Site, 2003.

Treatment	Av. % of leaves with insect damage (sample of 20)			
	June 17	July 11	August 14	
			Upper leaves	Lower leaves
No mulch	36.7a*	58.3 a	65.0 a	65.0 a
Mulch applied	13.3a	35.0 b	31.7 a	48.3 a

*means followed by the same letter within a column are not significantly different using the LSD test (P=0.05).

2004 - Lormar Orchard

Materials And Methods:

The trial was located in a row of eight year-old Honeywood bushes that were pruned in early spring. A wood-shavings mulch was applied on May 11, 2004 to 6m lengths of row, as described in the previous trial. The two treatments, mulched and no mulch applied, were replicated four times in a randomized design. No over-wintering plant material was removed from the bushes, but very few leaves or fruit were still attached. Kumulus was applied to the rest of the orchard but no chemical treatments were applied to the experimental row or adjacent rows.

Leaf and fruit samples were collected throughout the season, and examined for insect and disease damage. On June 3, 40 leaves were collected randomly from each of the treatments and the incidence of leaves with insect damage were recorded. No disease symptoms were present. On June 22, 40 leaves and 20 clusters of green fruit were sampled per treatment. The fruit were evaluated for the incidence of insect damage and mummy berry (caused by the fungus *Monilinia amelanchieris*). The incidence of insect damaged leaves was assessed. A very low incidence of *Entomosporium* infected leaves was noted. On July 13, the incidence of insect damaged leaves and the incidence of leaves infected with *Entomosporium* and rust were evaluated in 40-leaf samples. The incidence of insect, *Entomosporium*, rust and mummyberry damage was evaluated on the fruit from 20 clusters/treatment. Harvest was two weeks later than usual and the fruit was still red at this time. Final assessments of leaves damaged by insects and *Entomosporium* were made on 40-leaf samples on August 11, 2004. The percentage of fruit with insect and *Entomosporium* damage was also assessed on a 30- fruit cluster sample at this time.

Results and Discussion:

There were no significant differences in the incidence of leaves with insect damage (Table 3.3.5.3), or with *Entomosporium* infection (Table 3.3.5.4) at any of the sampling dates. However the mulched areas had lower levels of disease and insect damage in all but one sampling time (insect damage on June 3).

Table 3.3.5.3. Incidence Of Leaves With Insect Damage, Lormar Orchard 2004.

Treatment	Average incidence of insect damaged leaves sampled on:			
	June 3	June 22	July 13	August 11
No mulch	2.5	28.1	67.5	41.3
Mulch applied	5.6	25.0	55.0	34.4

*no significant differences between treatments using the Duncan's Multiple Range Test (P=0.1).

By the end of the season it was obvious to the naked eye that the mulched areas had retained more leaves (Figure 3.3.5.2). Early defoliation of saskatoons is usually caused by *Entomosporium* infection, thus mulching appeared to have reduced disease development.

Table 3.3.5.4. Incidence Of Leaves Infected With *Entomosporium*, Lormar Orchard 2004.

Treatment	Average incidence of diseased leaves sampled on:		
	June 22	July 13	August 11
No mulch	1.3	5.6	85.6
Mulch applied	0	3.1	81.3

*no significant differences between treatments using the Duncan's Multiple Range Test (P=0.1).

Fruit produced on bushes that were mulched also showed less damage than fruit on the unmulched areas (except for the July 13 sampling for insect damage) and there was significantly fewer fruit infected with berry spot when mature fruit were assessed on August 11 (Table 3.3.5.5).

Table 3.3.5.5. Incidence Of Fruit With Insect And Disease Damage, Lormar Orchard 2004.

Treatment	Average incidence of damaged fruit sampled on:						
	June 22		July 13			August 11	
	Insect damage	Mummy-berry	Insect damage	Berry spot	Mummy-berry	Insect damage	Berry spot
No mulch	84.6a*	7.3a	77.0a	4.3a	2.5a	8.5a	31.5a
Mulch applied	83.9a	1.5a	84.8a	2.3a	0.0a	3.7a	21.4b

* means followed by the same letter within a column are not significantly different using the Duncan's Multiple Range Test (P=0.1).

These results indicated that there were advantages to applying mulch to saskatoon bushes, and further examination of the effect of applying mulch is warranted.

2004 - Riverbend Plantation – New Bushes

Materials and Methods:

Riverbend Plantation has rows of very mature Smoky bushes at the southern edge of the orchard. Some of these rows have been removed at ground level and new growth allowed to establish from the mature root systems. A row of three year old new growth was used in a mulching trial in 2004.

When mulch is applied, any fallen leaves and fruit at the base of the bushes are covered. This may prevent the movement of fungal spores onto new growth in the spring, and also may deter the movement of insects that overwinter in the litter underneath the bushes. Removal of overwintering leaves and fruit from the bushes may also remove overwintering fungal inoculum. Treatments were designed to evaluate the effect of leaf and fruit removal, and of mulching, on control of insects and diseases

The row was marked into 6m sections and four treatments of 6m each were replicated four times in a randomized fashion within the row. The four treatments were:

1. no mulch applied, no leaf or fruit material removed
2. no mulch applied, overwintering leaf and fruit material removed
3. mulch applied, overwintering leaf and fruit material removed
4. mulch applied, no leaf or fruit material removed .

Mulch was applied, and the leaf and fruit material was removed from treatments two and three on April 14. In early May it was noted that some leaf material had blown onto the mulched areas, and an additional layer of mulch was added to cover these leaves.

Leaves were sampled (40 leaves per 6m treatment) on June 8, June 18 and July 9, and the incidence of leaves with insect damage, rust and *Entomosporium* infection recorded. Leaf samples were not taken later in July as defoliation due to leaf and berry spot infection occurred, and any samples taken would have been biased towards uninfected leaves.

Fruit samples, ten clusters/treatment, were collected on June 22. Insufficent fruit clusters were present on the new bushes for adequate samples to be taken in July. However, it was observed that by the end of July approximately half of the fruit were infected with *Entomosporium*. The percentage of fruit with insect damage and rust infection were recorded for the June sampling

Results And Discussion:

There were no significant differences in the disease levels on the leaves, or on the fruit sampled in June. The treatments were not expected to impact on rust development, as rust infection relies solely on airborne spores that are produced on galls on the alternate host plant, juniper. Although there were no significant effects of treatments on leaf and bery spot, it was observed that by mid August the bushes that were not mulched were more defoliated than the mulched areas. Early defoliation is a symptom of severe Entomosporium infection, and appreciable levels of disease occurred in the orchard (up to 50% of fruit was infected with berry spot by the end of July).

There were significant differences in the incidence of insect damaged leaves and fruit (Table 3.3.5.6). In the June 8 sampling, the incidence of insect damaged leaves was higher on bushes that were not mulched and had no over-wintering material removed, than on the mulched bushes with material removed. Both mulching and removal of material, together or separately, reduced the incidence of insect damage on leaves.

In the July sample, although the overall incidence of damaged leaves was higher, exactly the same result was found. The insect damage on the leaves was primarily caused by the hawthorn lacebug (*Corythucha cydoniae*). The larvae feed on the leaves and cause a mottlingof the foliage. They are not considered to be a serious pest, but at high levels they significantly reduce photosynthetic area which could cause an overall reduction in plant health and yield. The adults overwinter in leaf litter under the bushes, emerge in the spring and lay eggs on the underside of new leaves on the bushes.The eggs hatch into larvae in three weeks, and these larvae feed on the saskatoon leaves, causing damage. New adults hatch in mid-summer and the second generation completes its development by early fall, when the adults burrow back into leaf litter under the bushes, to over-winter (Insect Pests of Saskatoons. Alberta Agriculture, Food and Rural Development. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/opp2562). Spreading a layer of mulch over the leaf litter may hinder adult emergence in the spring, and may also alter conditions in the leaf litter, which would affect emergence patterns. The effect of mulching on insect damage should be studied further.

The incidence of insect damaged fruit was significantly reduced when overwintering material was removed from the bushes. Mulching did not have a significant effect, although the incidence of insect damage was lower on the mulched areas, compared with the unmulched areas. The main insect damage to the fruit was a small puncture wound

Table 3.3.5.6. Effect Of Mulching And Removal Of Over-wintering Material On The Incidence Of Insect Damaged Leaves, Riverbend Plantation, New Bushes 2004.

Treatment	Average incidence of leaves damaged by insects sampled on:		Average incidence of fruit damaged by insects sampled on:
	June 8	July 8	June 18
No mulch, no material removed	13.6 a*	39.4 a	80.3 a
No mulch, overwintering material removed	5.6 ab	24.4 ab	59.0 b
Mulch applied, overwintering material removed	5.0 b	21.9 b	53 .3 b
Mulch applied, no material removed	6.3 ab	26.9 ab	75.0 a

* means followed by the same letter within a column are not significantly different using the Duncan's Multiple Range Test (P=0.1).

caused by the apple curculio (*Tachypterellus quadrigibbus*), a reddish, brown weevil that overwinters in leaf litter, emerges in spring and lays its eggs in developing fruit. It is most surprising that removal of overwintering plant material appeared to reduce insect damage, as the insects have not been observed to survive in this material.

2004 - Riverbend Plantation – Mature Bushes

Materials And Methods:

A row of mature Smoky bushes, at least 12 years old, adjacent to the new bushes, were used in exactly the same trial as described previously. Mulch was applied on April 14, and the over-wintering leaf and fruit material was removed from bushes in treatments two and three on 12 May. It was noted that some leaf material had blown onto the mulched areas, and an additional layer of mulch was added to cover these leaves, on the same day the over-wintering material was removed.

Leaves were sampled (40 leaves per 6m treatment) on June 8, June 18 and July 12, and the incidence of leaves with insect damage, rust and *Entomosporium* infection recorded. Leaf samples were not taken later in July as defoliation due to leaf and berry spot infection occurred, and any samples taken would have been biased towards uninfected leaves. Fruit samples of 20 clusters were taken from each treatment on July 27 and the percentage of fruit damaged by insects, rust and berry spot was recorded.

Results and Discussion:

There were no significant differences in leaf disease levels except in the early June sampling, when the lowest incidence of rust occurred in the bushes without mulch and with over-wintering material attached (Table 3.3.5.7). This result is surprising as neither mulching nor removal of over-wintering material would be likely to impact infection by the air-borne rust spores that originate on juniper bushes some distance away from the saskatoon bushes. It was observed that the lowest incidence of *Entomosporium* infection occurred in the mulched areas, but these differences were not significant (Table 3.3.5.7).

Table 3.3.5.7. Effect Of Mulching And Removal Of Over-wintering Material On The Incidence Of Diseased Leaves, Riverbend Plantation, Mature Bushes 2004.

Treatment	Average % leaves infected with		Average % fruit infected with	
	Rust on June 8	*Entomosporium* on July 12	*Entomosporium* on June 12	*Entomosporium* on July 27
No mulch, no material removed	11.3a*	10.6 a	11.5 a	29.7 a
No mulch, overwintering material removed	16.9 ab	6.9 a	15.3 a	23.4 a
Mulch applied, overwintering material removed	18.1b	5.0 a	8.0 a	17.7 a
Mulch applied, no material removed	19.4 b	3.1 a	3.0 a	17.8 a

* means followed by the same letter within a column are not significantly different using the Duncan's Multiple Range Test (P=0.1).

There were no significant differences in disease incidence on the fruit sampled in June or July, although lower levels of disease were observed on the mulched areas (Table 3.3.5.7). These results indicate that further evaluation of the impact of mulching on disease development is warranted.

There was a significantly higher incidence of insect damaged fruit on bushes with over-wintering material left on the bushes, than when this material was removed (Table 3.3.5.8). This effect was also observed in the new bushes, and warrants further investigation. Mulching did not appear to affect insect damage to the fruit.

Table 3.3.5.8. Effect Of Mulching And Removal Of Over-wintering Material On The Incidence Of Insect Damaged Fruit, Riverbend Plantation, Mature Bushes 2004.

Treatment	Average % of fruit with insect damage, sampled July 27
No mulch, no material removed	56.4 a*
No mulch, overwintering material removed	39.5 b
Mulch applied, overwintering material removed	49.3 ab
Mulch applied, no material removed	57.3 a

* means followed by the same letter within a column are not significantly different using the Duncan's Multiple Range Test (P=0.1).

3.3.6. Evaluation Of Saskatoon Material For Resistance To *Entomosporium* Leaf And Berry Spot And Saskatoon-juniper Rust.

In 2002 -2003, a number of genotypes of saskatoon were evaluated for resistance to the two main diseases that impact saskatoon production, *Entomosporium* leaf and berry spot and saskatoon-juniper rust. These genotypes represented material selected from wild plants showing desirable characteristics, growing in the Prairie provinces and Montana. Each plant from a specific location was given an accession number, and the seed collected from the fruit of these wild plants were germinated and the resulting progeny put into tissue culture. The resulting progeny were given sub numbers, i.e. plant number 2 had at least 24 progeny, and they were labelled 2-1 to 2-24. Thus all progeny with the same first number came from one plant originally.

The procedure used to evaluate the response of the plants to *Entomosporium* infection was developed by Ronald and St- Pierre (**In** Ronald, P.S. and St-Pierre, R.G. 2002. Infection process of *Entomosporium mespili* on leaves of saskatoon, *Amelanchier alnifolia*. Can. J. Plant Pathol. 24(3):363-371.). This procedure involves removing young leaves from the seedlings, and inoculating them with the pathogen. After an incubation period the leaves were evaluated for disease symptoms. The evaluation of plants to rust infection was also carried out by exposure of seedlings to natural inoculum in the field.

Materials and Methods:

The saskatoon seedlings initially produced by tissue culture were transplanted into six inch (one gallon) pots. The seedlings were kept in a cold room (5°C) in a dormant state until 3-4 weeks prior to testing (Figure 3.3.6.1). They were then placed in a growth cabinet with a 14 hour day/10 hour night cycle, day temperature of 20°C and night temperature of 16°C, to initiate leaf production (Figure 3.3.6.2). Young shoots were removed from the seedlings, and 16 of the youngest, expanded leaves selected for testing

for resistance. The leaf petioles were placed through holes in a sheet of polystyrene floating on distilled water contained in rectangular plastic boxes (Figure 3.3.6.3). The leaves were excised under water to prevent air bubbles from entering the cut petioles. A total of 28 leaves, four leaves of each of seven genotypes, were distributed evenly in the box. Four boxes were used in each test, the leaves in three of them were sprayed with a fungal spore suspension, and the leaves in the fourth box were sprayed with distilled water, as a control.

The spores of *E. mespili* were obtained from lesions produced by natural infection of bushes in 2002. Dry, infected leaves were stored at 4°C. Prior to inoculum production the leaves were moistened to encourage spore release. In order to produce a suspension containing predominantly *Entomosporium* spores a technique mimicking natural dispersal was developed. Individual droplets of distilled water were dropped onto lesions containing acervuli, resulting in grey masses of spores oozing out of the acervuli. These droplets of water encouraged the release of large numbers of almost exclusively *Entomosporium* spores, which were collected using a fine pipette. The resulting droplet suspension was diluted to produce a spore suspension of approximately 1×10^4 spores/ml. This suspension was sprayed over the leaves until individual droplets were formed on the upper surface of the leaves.

Lids were replaced on the boxes after inoculation. The boxes were then enclosed in black, plastic bags for the next 48 hours to reduce light and increase humidity in order to create conditions most favourable for infection. The leaves were incubated at 20°C in the boxes for 12 days with a 14 hour day/10 hour night cycle. After the incubation period the leaves were examined for signs of infection. Typically chlorosis and/or necrosis were seen in some genotypes, as well as the production of necrotic spots with the presence of acervuli (Figure 3.3.6.4). Only tests in which Smoky leaves developed lesions were included in the results, to ensure that the spore suspensions used were viable, and capable of infecting a susceptible cultivar, except for the last two tests in January 2003 when there were no Smoky seedlings available. In both these tests infection occurred on almost all of the test material, indicating that the spore suspensions were viable. The reactions of the different genotypes were then compared with that of Smoky.

Of the 57 genotypes available for increase by tissue culture 26 developed sufficient seedling material for testing between October 2002 and January 2003. A minimum of two inoculation tests was carried out on these seedlings, ensuring that the percentage of leaves infected was based on the inoculation of at least 24 leaves. Observations were also made on the reaction of genotypes to mildew infection, which occurs sporadically under greenhouse conditions. Mildew developed on the leaves during some of the tests, and when this occurred the material showing resistance to mildew was noted.

The same material evaluated in the detached leaf test was also exposed to natural infection by placing two potted seedlings of each genotype in the Accession orchard from the end of May until July 29. By the end of July 100% of the Smoky leaves were infected with leaf and berry spot. The percentage of leaves infected was assessed for all exposed seedlings.

Assessment of seedling resistance to rust infection using a seedling inoculation technique developed by Kabaluk and St. Pierre (**In** Kabaluk, J.T. and St-Pierre, R.G.1992. A technique for screening seedlings of the saskatoon for resistance to the rust *Gymnosporangium nelsonii*. Can. J. Plant Sci. 72:627-630.) was attempted. In this technique seedlings are sprayed with a suspension of rust spores, and the reaction is evaluated. Rust gall material collected in May 2002 did not produce infective spores. Unfortunately levels of natural rust infections were very low in 2003, and there was insufficient disease developed on the exposed seedlings to evaluate their response to natural inoculum.

Results and Discussion:

The commercial cultivars Pearson, Smoky and Success all had over 30% of their leaves infected in the detached leaf test (Table 3.3.6.1). Sixteen of the 26 genotypes had fewer infected leaves than Smoky, indicating they might have resistance to the pathogen. Genotypes originating from the same wild plant had similar reactions, except for the genotype 20- , when 20-15 developed a lot less infection than 20-10 and 20-11. The genotypes A1and A3 had only slightly fewer leaves infected than Smoky and, like A2, would not be considered resistant to the pathogen. No disease developed on the uninoculated controls.

The genotypes originating from the plants labelled 2-, 9-, 13-, and 22- all had fewer than 14% leaves infected and these genotypes could provide valuable sources of disease resistance. These genotypes also showed less infection of the seedlings exposed to natural infection in most cases. However the results of natural inoculation were variable and more extensive testing of these genotypes under field conditions is necessary.

Mildew resistance was observed on two genotypes, 14-1 and 14-33. Both these genotypes had lower *Entomosporium* infection levels than Smoky, and should also be included in future tests.

Further evaluation of seedlings showing lower susceptibility to *Entomosporium* and rust, and incorporation of resistance into new cultivars would be of tremendous value to the saskatoon industry.

Table 3.3.6.1. Response Of Saskatoon Seedling Genotypes To Artificial Inoculation Of Detached Leaves And Exposure Of Whole Seedlings To Natural Inoculum Of *E. mespili*.

Genotype number/name	No. of inoculation tests conducted	% of leaves infected (average of all tests)	Genotypes with lower % of leaves infected than Smoky	% of infected leaves on seedlings exposed to natural inoculum (2 plants)
2-10	3	8	yes	48, na*
2-24	2	4	yes	100, na
5-48	3	55	no	64,37
9-53	2	4	yes	29,71
13-31	4	6	yes	68,68
13-47	2	13	yes	79,96
14-1	3	22	yes	100,76
14-33	2	8	yes	na
14-35	3	28	yes	12,92
16-7	3	55	no	100,71
16-27	3	42	no	93,51
17-11	3	47	no	86,78
18-39	2	25	yes	41,100
20-10	3	50	no	91,71
20-11	3	55	no	93,82
20-15	2	8	yes	na
21-44	3	19	yes	41,93
21-49	2	25	yes	83,96
22-19	2	0	yes	na
24-24	2	50	no	na
29-3	2	58	no	72,70
A1	3	28	yes	100,98
A2	2	50	no	45,79
A3	2	29	yes	75,56
Meadow Lake	2	37	no	100,73
Redberry	2	21	yes	100,88
Pearson	2	37	no	100,88
Success	3	47	no	80,55
Smoky	10	32		100,100

*na means plant not available.

3.4. Conclusions

Infected leaves, pedicels and fruit remaining on saskatoon bushes over the winter, and detached leaves that had fallen to the ground below the bushes, were all capable of producing spores of *E. mespili* in the spring, under conditions of high humidity and warm temperatures. Even when dry summer conditions occurred, late season infections survived the winter to produce over-wintering inoculum on fruit and leaves, both attached and detached. This material provided the potential for significant levels of disease to develop under ideal climatic conditions. When weather conditions are favourable for disease producers need to be on the alert for outbreaks of leaf and berry spot regardless of the levels of disease the previous season. Removal of infected material both on and under bushes might impact disease development in the spring.

Spores of *E. mespili* were found in water samples collected from infected bushes in 2002, indicating that spores are splashed around within the bush canopy during rainfall. The spores were present in the water collected on only three occasions. This low level of spore collection was due to either a reduced presence of spores in the generally dry summer, or the collection method was not adequate to monitor spore movement.

Spores of *E. mespili* were also present in the sample tubes used to collect rainfall in a spore trap in August 2003. Although disease symptoms were observed on small seedlings between rows in June, spores were not trapped in the sampler until infection had moved to leaves higher up on the bushes. The sampler did not collect the spores responsible for the first infections that occurred on the small seedlings early in the season in 2003. Rain splash may not have been high enough to allow trapping of the spores produced near the ground.

These two methods did not provide an early detection system for the presence of spores of the pathogen, and thus could not be used in a forecasting system.

The fungicide, Sovran, reduced disease incidence of leaf and berry spot in 2001. It appeared to be effective for a longer period than Topas in controlling leaf and berry spot, but was not as effective in controlling rust in 2002. Use of a fungicide such as Sovran, with a different chemistry, would assist growers in preventing the development of pathogen resistance to specific chemicals. Unfortunately Minor Use Registration of Sovran was not approved by the Pest Management Regulatory Agency in 2002 and further testing of Sovran was discontinued.

In 2002, fungicide treatments of Topas and BAS 516 were effective at controlling saskatoon-juniper rust. However, disease levels of leaf and berry spot were too low for adequate evaluation of fungicide control measures of this disease. One and two applications of Topas consistently reduced the percentage of rust infected leaves in all trials. Two applications of BAS 516 were as effective as two applications of Topas, except for a slight reduction in control in August at the accession orchard. BAS 516 is a combination of two broad-spectrum fungicides, one of which will be registered in 2003. Registration of BAS 516 is anticipated in 2004. Continued testing of this product would

allow for application for Minor Use Registration soon after the product has received registration for use on other crops.

Disease levels of leaf and berry spot developed too late in 2003 for adequate evaluation of fungicide control measures for this disease. However the bushes sprayed with Topas and BAS 516 in June still had the lowest levels of disease in July and August. An outbreak of brown fruit rot allowed an evaluation of the control of this disease by the chemicals applied in May 2003. Topas and BAS 516 both reduced the incidence of brown fruit rot and increased the total number of fruit produced by the bushes, although Topas was more effective than BAS 516. The alternative products Fungineem and Melaleuca Oil were evaluated but no fungicidal effect was observed.

Applications of BAS 516 reduced levels of both leaf and berry spot as effectively as Topas applications in 2004. However this product does not seem quite as effective in controlling rust infection and further testing is recommended.

Application of protectant fungicides to saskatoons on a regular basis results in reduced disease inoculum. However, continued evaluation of new products is important for the development of integrated pest management strategies, which do not rely on the persistent use of one control product. It is also possible that a post-harvest spray would prevent disease build up at the end of the season which, in turn, would reduce the amount of infected material available for over-wintering. Evaluation of this strategy is also recommended.

Pruning treatments at one site (Riverbend) reduced yield when compared with unpruned bushes in 2001. At the second site (Last Mountain) pruning did not significantly impact yield. Pruning did not affect disease levels, probably as the lengths of treated row were short (2m) which may not have significantly affected air movement and humidity in that area.

In 2002 at the Lormar site, significantly lower levels of leaf and berry spot developed on the bushes that were most heavily pruned. At this site, rows were widely spaced facilitating greater air movement within the orchard. Pruning probably increased air circulation within the bushes resulting in lower humidity levels. The impact of pruning was less evident at the Accession Orchard, where lower overall levels of disease occurred. The most heavily pruned bushes developed less leaf and berry spot than the more lightly pruned bushes. The incidence of rust in the Accession Orchard trial was lowest on unpruned bushes in June, but not significantly different from that of pruned bushes by mid-August. This may reflect the increased amount of new leaf tissue produced by pruned bushes at the beginning of the season, which is more susceptible to rust infection. Pruning may impact disease levels both by altering the proportion of new shoot growth as well as the microclimate. At the second pruning trial initiated at Last Mountain Berry Farm in the fall of 2001, disease incidence was low and no differences were observed between treatments.

In 2003, there was a significant reduction in insect damage of the fruit on the more severely pruned bushes at the Lormar orchard, and there was an increase in fruit yield for the bushes pruned by 1/3.

Although pruning treatments did not consistently reduce disease levels the beneficial effects on yield and general health of the bushes support the recommendation that bushes be pruned regularly to remove older wood and excessive sucker growth. A pruning regime where this material is removed on a regular basis would help maintain orchards in a productive state that would be less susceptible to insect and disease damage. Even the severe pruning regime only reduced yield in the first season, showing that producers can prune aggressively when necessary.

Preliminary assessments of the value of mulching under saskatoon bushes for the control of leaf and berry spot indicate that a slight reduction in incidence and severity of disease was achieved, in a year when disease pressure was not high (2003). Insect damage was also reduced.

In more extensive trials in 2004, there were visible differences observed between the treatments at two locations, although the effects of applying mulch were not statistically measurable. The defoliation of bushes in mulched rows was obviously delayed, probably because of reduced infection by *E.mespili*. The results suggest that mulching has the potential to reduce levels of both disease and insect damage. Mulching also has the advantage of helping with moisture conservation and weed control. The only disadvantage is the possibility of rodent damage when mulch material provides cover around the stems. Further evaluation of this control strategy is recommended.

The detached leaf assay test identified a number of saskatoon genotypes that developed less leaf and berry spot infection than three of the currently grown cultivars. Further assessment of the response of these seedlings when exposed to natural infection of leaf and berry spot and saskatoon-juniper rust in the field is recommended. Growth characteristics and yield data should also be considered, before producers are provided with the material.

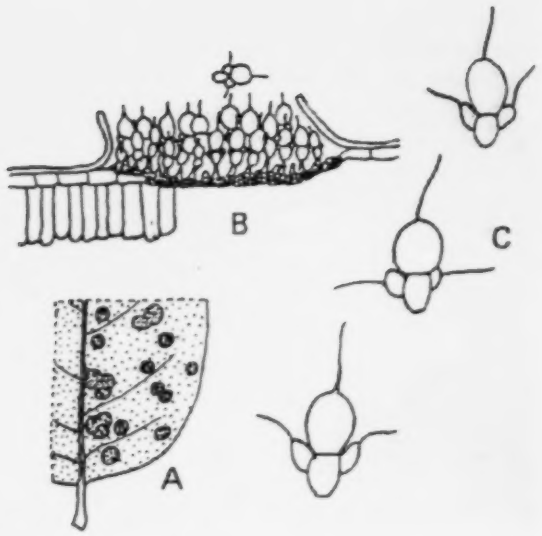


Figure 3.1.1. Reproductive structures of *Entomosporium mespili*. A) Acervuli on leaf; B) Section through acervulus; C) Distinctive asexual spores (conidia). (From Illustrated genera of Imperfect Fungi. 1972. Barnett & Hunter.)

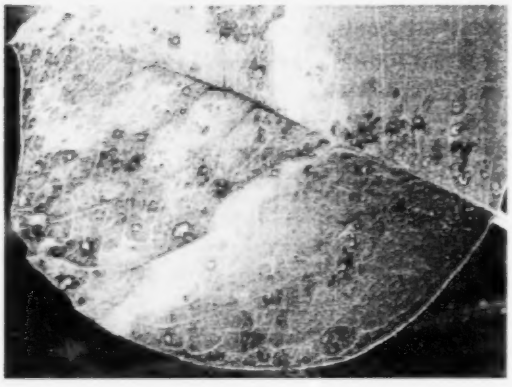


Figure 3.1.2. Sporulating lesions of *Entomosporium mespili* on saskatoon leaf. Note grey areas where masses of spores are formed.

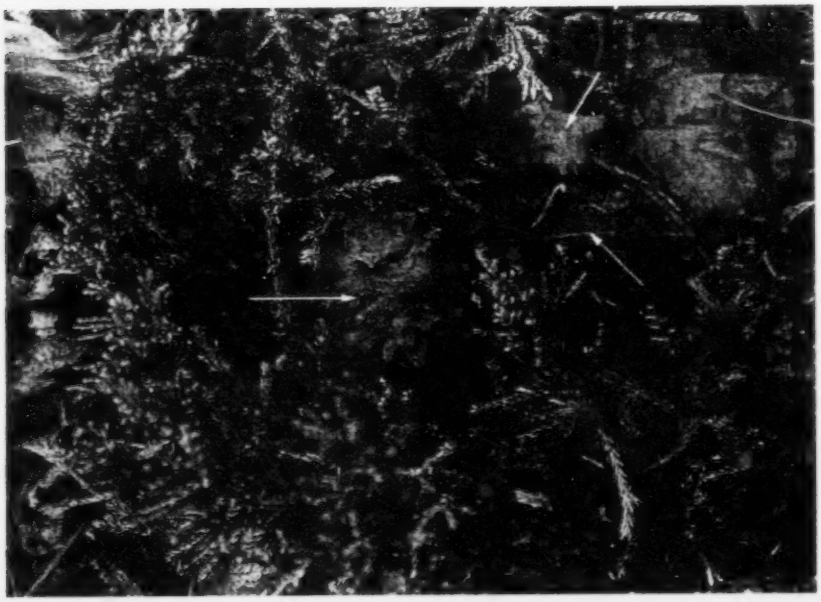


Figure 3.1.3. Fleshy galls of *Gymnosporangium* sp. on juniper.

Figure 3.1.4. Aecia of saskatoon-juniper rust pathogen on saskatoon fruit.

Figure 3.3.4.1. Pruning site at Last Mountain Berry Farm, April 2001.

Figure 3.3.4.2. Pruning site at Last Mountain Berry Farm, July 2001.

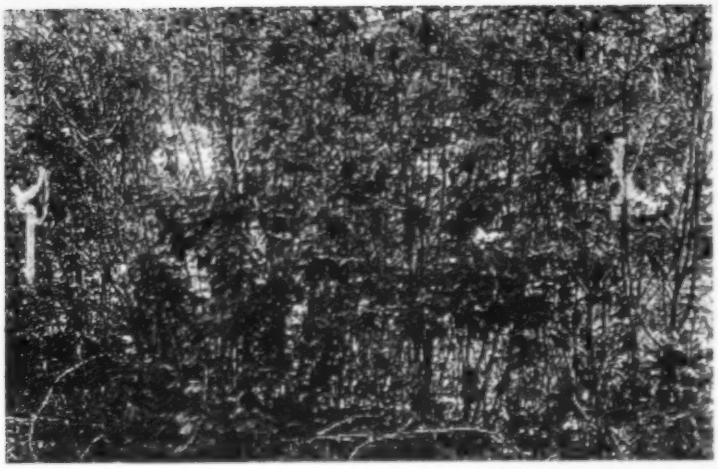


Figure 3.3.4.3. Unpruned treatment at Riverbend Plantation, May 2001.

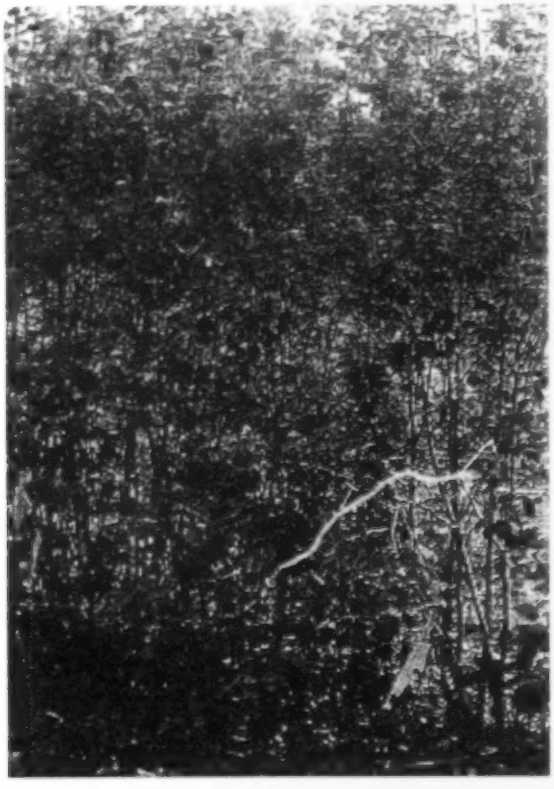


Figure 3.3.4.4. One third of plant material removed, Riverbend Plantation, May 2001.

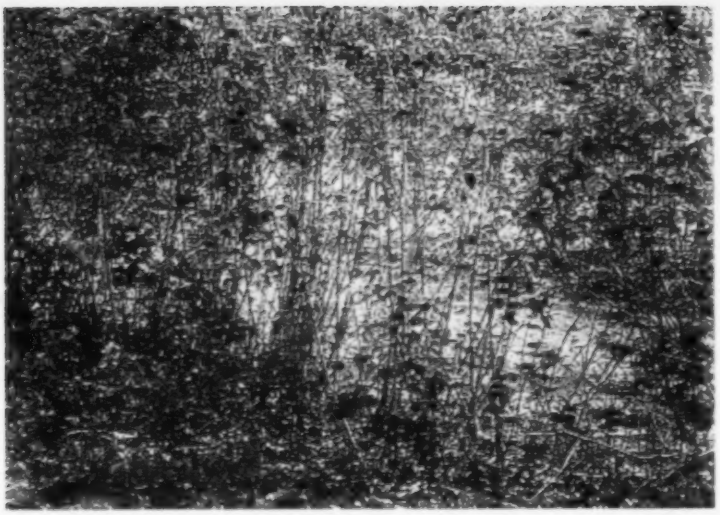


Figure 3.3.4.5. Two thirds of plant material removed, Riverbend Plantation, May 2001.

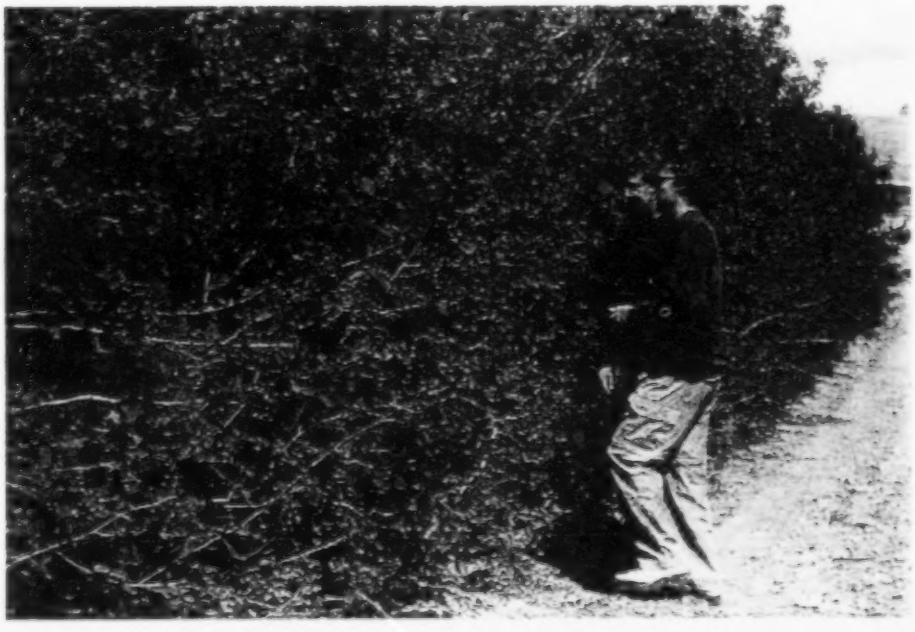


Figure 3.3.4.6. Mature Smoky bushes at Last Mountain Berry Farm, June 2001, prior to fall pruning in 2001.

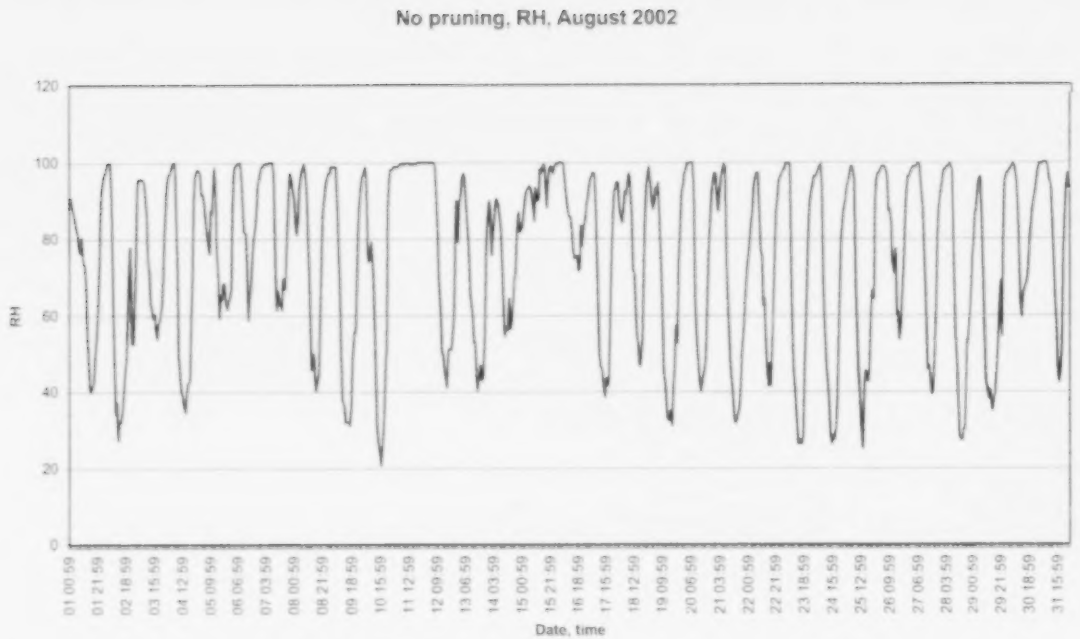


Figure 3.3.4.7. Relative humidity in unpruned treatment, accession orchard, in August 2002.

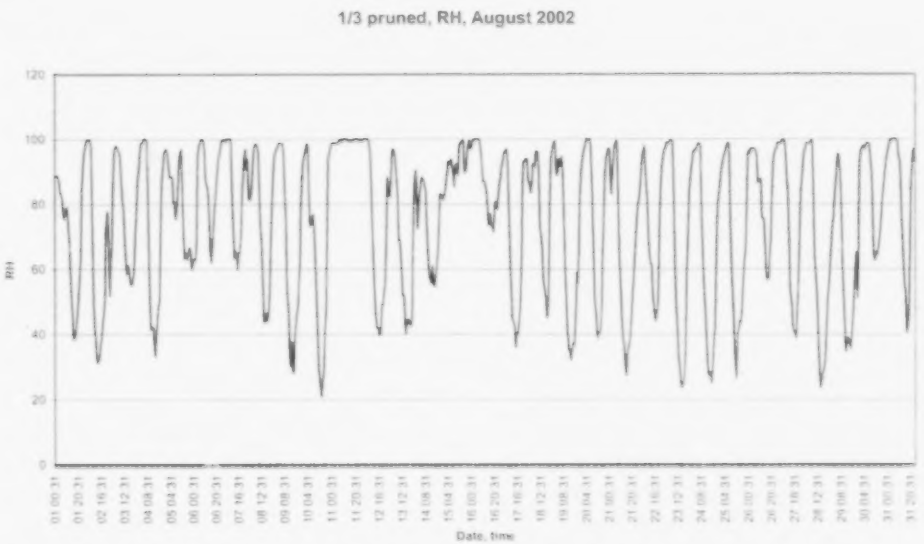


Figure 3.3.4.8. Relative humidity in 1/3 pruned treatment, accession orchard, in August 2002.

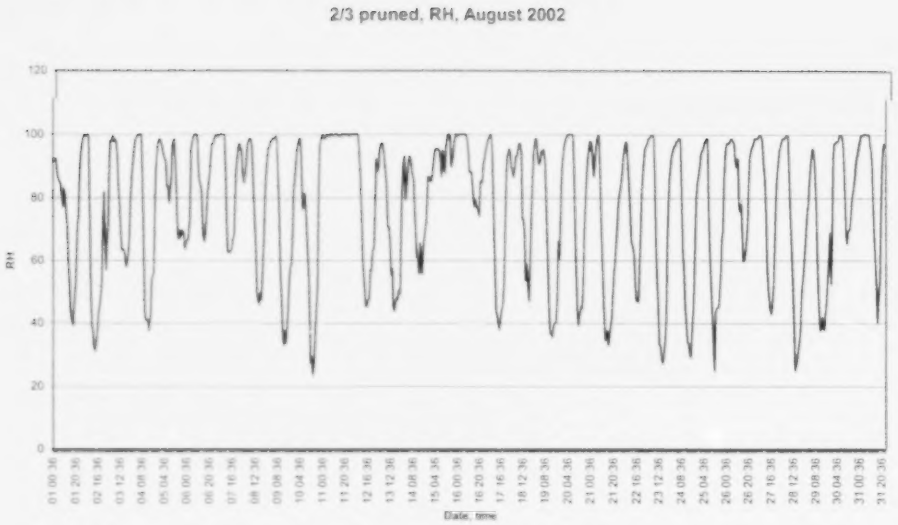


Figure 3.3.4.9. Relative humidity in 2/3 pruned treatment, accession orchard, in August 2002.

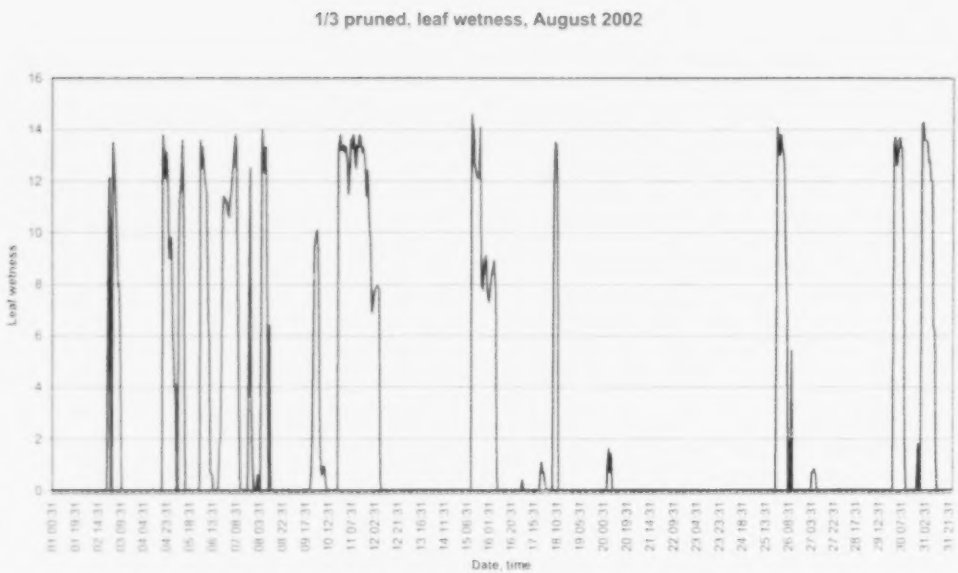


Figure 3.3.4.10. Leaf wetness recorded in 1/3 pruned treatment, accession orchard, for August 2002.

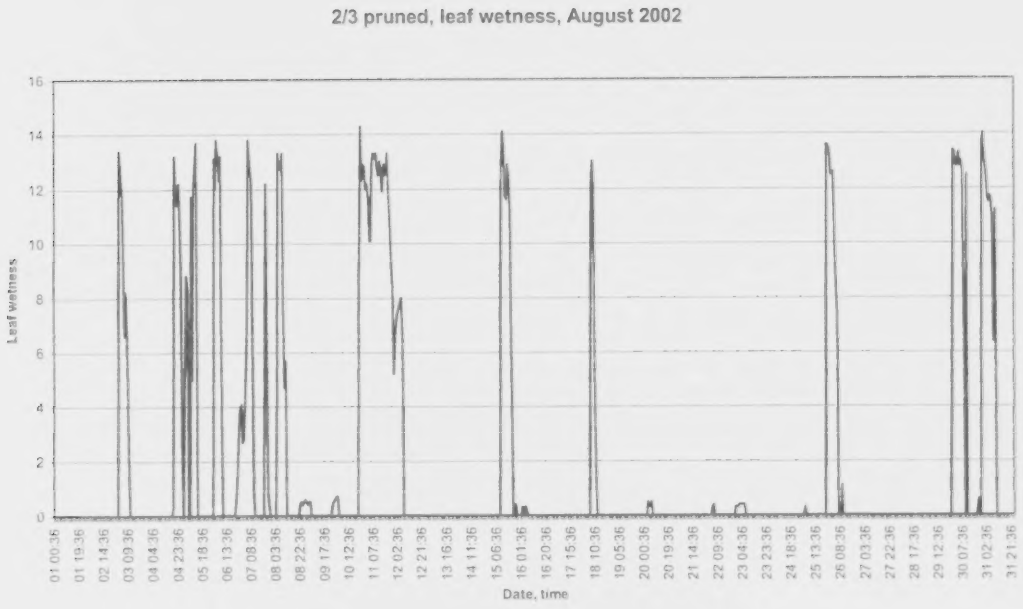
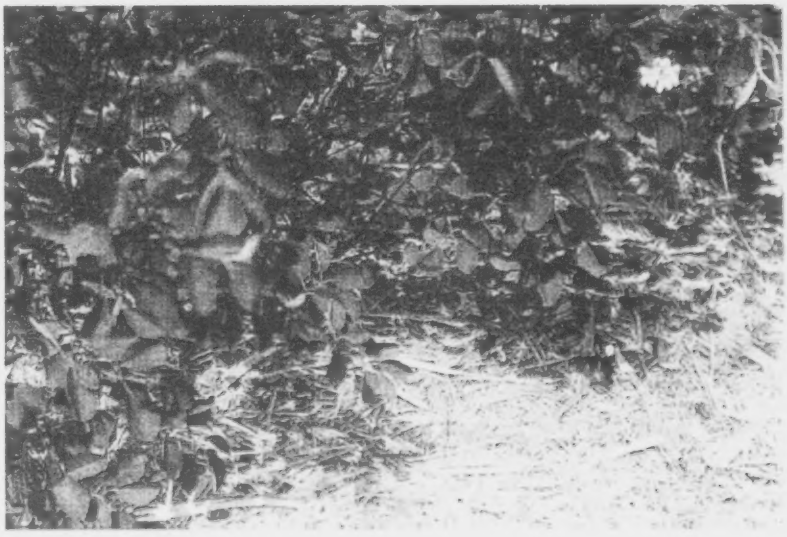


Figure 3.3.4.11. Leaf wetness recorded in 2/3 pruned treatment, accession orchard, for August 2002.

A.



B.

Figure 3.3.5.1. Saskatoon bushes mulched at Lormar Orchard. May 2003. A) Mulched and unmulched areas in same row. B) Mulched area showing all leaf material under the bush was covered.

Figure 3.3.5.2. In the second mulching trial at Lormar Orchard, bushes in the non-mulched area of the row (left-hand side) were more defoliated than in the mulched area (right-hand side) by mid-August, 2004.

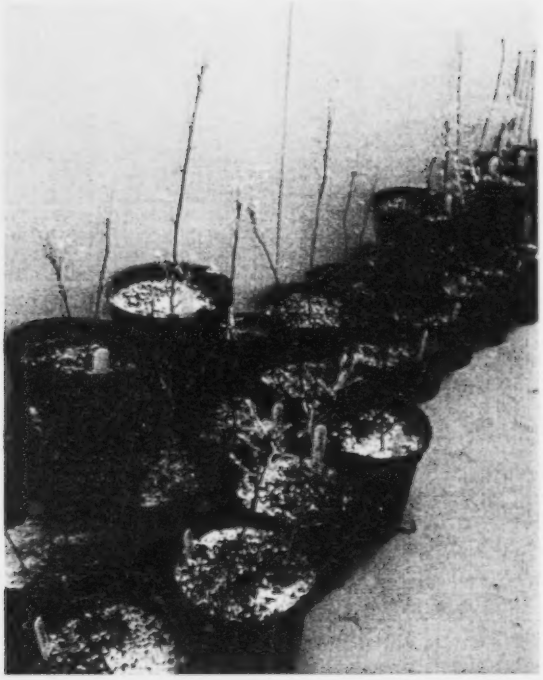


Figure 3.3.6.1. Potted saskatoon seedlings stored in cold room at 5°C .

Figure 3.3.6.2. Seedlings after approximately 4 weeks in growth cabinet have developed sufficient leaves for detached leaf testing.

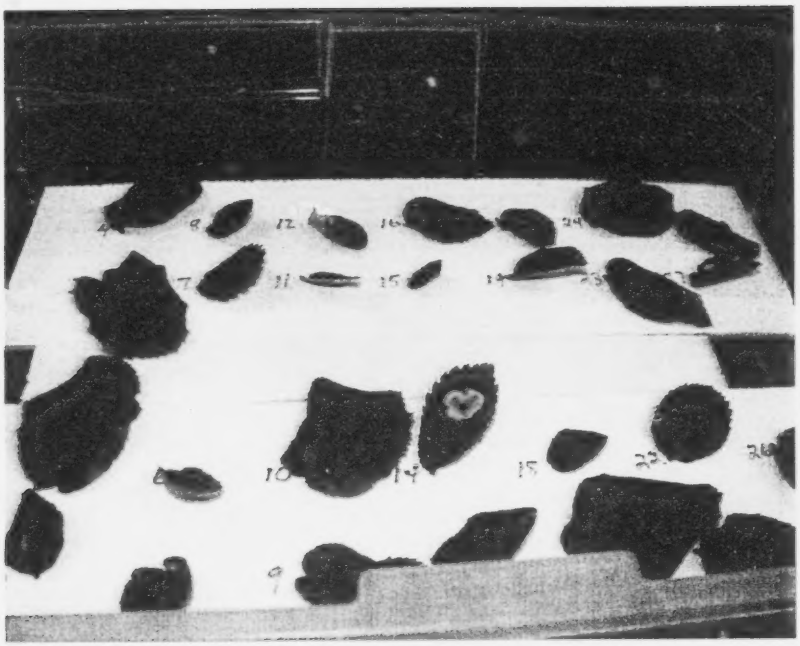


Figure 3.3.6.3. Detached leaves in plastic boxes, prior to inoculation with spore suspension of *E.mespili*.

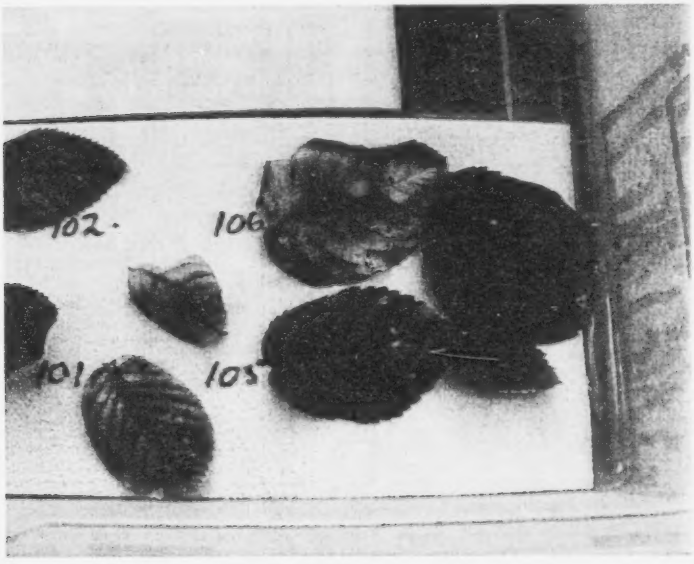


Figure 3.3.6.4. Inoculated leaves with dark, necrotic spots typical of infection by *E. mespili*.

4. PERSONNEL

2001
R. St-Pierre – 5%
J. Thomson – 25%
M. McArthur – 25%
L. Dupuis – 25%

2002
R. St-Pierre – 5%
J. Thomson – 80%
M. McArthur – 80%
R. Ingram – 5%
A. Krahn – 5%

2003
R. St-Pierre – 5%
J. Thomson – 80%
M. McArthur – 80%
A. Glaze -casual

2004
R. Bors – 5%
J. Thomson – 80%
M. McArthur – 80%
J. Norwig – 15%

5. EQUIPMENT

Rental of spore sampling machine.

6. PROJECT DEVELOPED MATERIALS

Presentations:

St-Pierre, R.G. 2001. Native Fruit Development Program - Research Highlights 2001. Saskatchewan Fruit Growers' Association Annual Conference, Saskatoon, SK. November 23-24.

St-Pierre, R.G. 2001. Integrated pest management for Saskatchewan fruit orchards. Saskatchewan Fruit Growers' Association Annual Conference, Saskatoon, SK. November 23-24.

St-Pierre, R.G. 2002. Saskatchewan Fruit Growers Association Field Tour.

St-Pierre, R.G. 2003. Saskatchewan Fruit Growers Association Field Tour.

Thomson, Jill. Nov 22, 2003. Integrated Pest Management of Diseases of Saskatoons. SFGA meeting, Saskatoon.

Thomson Jill. 2005. Research into integrated pest management strategies for control of diseases of saskatoons. Prairie Fruit Journal, Vol. 12, Issue 1, p.3.

7. PROJECT PHOTOS

Included with report.

8. ACKNOWLEDGEMENTS

In:

St-Pierre, R.G. 2001. Native Fruit Development Program - Research Highlights 2001. Saskatchewan Fruit Growers' Association Annual Conference, Saskatoon, SK. November 23-24.

St-Pierre, R.G. 2001. Integrated pest management for Saskatchewan fruit orchards. Saskatchewan Fruit Growers' Association Annual Conference, Saskatoon, SK. November 23-24.

St-Pierre, R.G. 2002. Saskatchewan Fruit Growers Association Field Tour.

St-Pierre, R.G. 2003. Saskatchewan Fruit Growers Association Field Tour.

Thomson, Jill. Nov 22, 2003. Integrated Pest Management of Diseases of Saskatoons. SFGA meeting, Saskatoon.

Thomson Jill. 2005. Research into integrated pest management strategies for control of diseases of saskatoons. Prairie Fruit Journal, Vol. 12, Issue 1, p.3